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TROPICAL CYCLONES

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TROPICAL CYCLONES

COMPRISING

EXHAUSTIVE STUDY ALONG ENTIRELY NEW LINES OF THE DISTRIBUTION OF WIND DIRECTIONS AND VELOCITIES, CLOUDS, PRECIPITATION, AND OTHER FEATURES OBSERVED AND RECORDED IN SIXTEEN TROPICAL CYCLONES WHICH HAVE MOVED IN ON THE GULF AND SOUTH ATLANTIC COASTS DURING THE TWENTY-FIVE YEARS, 1900 TO 1924 INCLUSIVE, WITH DEDUCTIONS CONCERNING THE CAUSES OF THE DISTRIBUTION OF WINDS AND PRECIPITATION IN CYCLONES, THE DEVELOPMENT AND MOVEMENT OF CYCLONES, AND THE PASSING OF THE CYCLONE FROM THE TROPICAL TO THE EXTRATROPICAL LATITUDES.

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BY

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PREFACE

Tropical cyclones, which frequently are attended by wind
ocities of 100 to 140 miles per hour with probably greater
ocities in some instances in certain parts of the cyclonic area,
agents of great destruction, not only to shipping in the open
s but to all classes of structures on islands and coast lines
continents. More than 6,000 human beings have lost their
es in a single tropical cyclone on this continent and many
re lives have been taken by such cyclones on other conti-
ts, largely because of the fact that no extensive data and
dies on which to base plans for protection had been published.
residence on the Mexican Gulf coast at Galveston, Texas,
New Orleans, La., from 1889 to date (37 years), as meteor-
gist and district forecaster in the Weather Bureau has im-
ssed the writer with the importance of this subject, not
y as regards the warning service for the protection of life and
perty, and as an aid to construction and reclamation
ineers in safeguarding against future loss of life and prop-
, but from the scientific point of view as well. Stations of
United States Weather Bureau, along the Atlantic and
xican Gulf coasts, were equipped with complete automatic
ording meteorological instruments prior to the year 1900,
all the data recorded in tropical cyclones during the suc-
ding 25 years are given in tables and considered in this work.
Certain phenomena recorded in connection with tropical
lones can not be explained by the generally accepted ideas
current theories regarding the action of the winds and the
ribution of precipitation about the cyclonic center.

tudies of cyclones heretofore have been based mainly on
optic charts which do not enable the representation of the
ds and other elements in their true relations to the move-
nt of the center of cyclones. An important feature in this
k is a new method which has been devised for charting the
d directions and velocities, the precipitation, and other ele-
nts, which occur around the cyclonic center as the cyclone
ances. This method makes possible for the first time, in

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the study of cyclones, the correct representation of the win direction and velocity, the distribution of precipitation, and th cloud movements, as related to the cyclonic center in bot traveling and stationary cyclones. The cloud observations i these cyclones furnish a much greater amount of upper air dat than has previously been available in the study of cyclones. Th study of all the data here assembled brings out facts materiall different from those generally represented in connection wit the phenomena of cyclones. These data show that the a current, in which the cyclone travels, materially influences th direction and the velocity of the winds in the different par of the cyclone at the earth's surface, and by bringing about th convergence of winds determines to a great extent the distribu tion of precipitation in the cyclone and causes the center the cyclone to move towards the area of greatest precipitatio intensity. The movements of the upper clouds do not sho a radial outflow of cirrus from the center of the cyclones.

This work will be of value for all time because the larg amount of original matter contained therein is presented in manner which makes it available in convenient form for use checking these and other studies of cyclones not only in th region but in any part of the world and for use of meteorologic students, teachers, and engineers in further investigations a subject of primary importance in the advancement meteorology. The mathematician will find problems and dat fruitful for mathematical research. No such complete dat bearing on the fundamental phenomena of the cyclone have bee assembled and published for any part of the world.

Numerous requests received for a paper by the writer "Relation of Changes in Storm Tides on the Coast of the Gu of Mexico to the Center and Movement of Hurricanes," com pleted in 1919 and published in the Monthly Weather Revie March, 1920, show that there is a demand for a work givin complete data and deductions regarding tropical cyclones in th region. This paper is republished here in "Appendix A."

In view of the original methods followed in the preparatio of this work and the conflicts in some of the conclusions, base on the most complete data available, with preconceived ide and current theories I expect some meteorologists to take

ition opposing my conclusions. I ask such differing meteor-
gists to show:
1) Wherein the methods of analysis and presentation are not
nd and legitimate.
2) Wherein the observational data are not accurate, ade-
te, and definite.
3) Wherein the inferences and interpretations of the evi-
ce are not justified and correct.
4) Where conflict arises with reference to preconceived ideas
current theories to show the advantage of such ideas or
ories over the views, explaining the causes of the phenomena
the cyclone, advanced in this work.

Acknowledgment is made here to Prof. C. F. Marvin, Chief
the Weather Bureau, whose suggestions have aided me mate-
ly in the preparation of this work, and to other Weather
reau officials who have rendered valued assistance.

This study was completed in 1922, brought up to date in 1924,
l since then has been slightly modified and arranged for
olication.

ISAAC MONROE CLINE.

w Orleans, La.,
ober 13, 1925.

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TROPICAL CYCLONES

Synopsis

The intensity of and destructiveness attending tropical cyclones make it of primary importance, both from a scientific and economic point of view, that their characteristics be determined from the most complete records available. Regions where no mountains are present to influence winds and precipitation and where complete records are available at several stations within the area traversed by the cyclones furnish the best field for study of such phenomena. The records in tropical cyclones which have moved in over the Gulf and South Atlantic regions during the last 25 years have been assembled and discussed. Tables are given which show the detailed hourly records and observations at from three to five stations in each cyclone during the time the stations were within the cyclonic area. These are given for sixteen cyclones which furnish a much larger amount of data within the cyclonic area proper than heretofore have been used in the studies of these disturbances.

In this study a new method has been devised for charting meteorological records during the passage of tropical cyclones. This method gives a diagram showing the phenomena at many points in different portions of the cyclonic area, in their proper relation to the cyclonic center at the time recorded, which is approximately equivalent to greatly multiplying the number of observing points within the cyclonic area on a synoptic chart. However, this method goes beyond the synoptic chart in the power to represent the conditions as related to a storm center with a continuous changing movement over the earth's surface. The meteorological conditions which prevail in the different parts of each cyclone are shown on separate charts. These charts contain the wind directions and velocities, precipitation intensity, and the cloud directions recorded during the passage of the cyclone. Complete and detailed distribution of precipitation along the path of a tropical cyclone is shown in one case covering its passage through a period of five days and over a distance of 2000 miles after it moved inland on the Gulf Coast.

Isobaric charts based on the most complete barometric read
ings of record, in tropical cyclones, showing isobars and signifi
cant changes in their shapes, and variations in the intensity o
the cyclone at short intervals of time as the storm advanced
are given for three of the largest and most intense cyclones
The mass of detailed data presented brings out some im
portant facts. Surface winds about the cyclonic center ar
influenced in a pronounced manner by the air current in whic
the cyclone travels. In the right rear quadrant the winds blo
strongly in the same general direction as that in which th
cyclone is traveling. A decided convergence of the winds of th
right rear quadrant with those of the right front quadrant occur
in the neighborhood of the line dividing the storm area int
front and rear halves. The winds are strongest in the right hal
while in the left half they are much weaker with a genera
movement back along the line of advance and a rather shar
incurvature in the rear towards the strong indraught of th
winds in the right rear quadrant. The precipitation occur
mainly in the right front quadrant of the cyclones that continu
to advance, and is the result of the wind movements in travelin
cyclones. In cyclones which cease to advance the precipitatio
occurs both in the front and rear of the cyclonic area, with th
area of lowest pressure shifting towards the region of greates
precipitation intensity, and such storms soon die out or after
few days move off slowly, as very weak, ill-defined disturbance
The source of moisture supply in the cyclones is through th
winds in the right rear quadrant.

The position of heaviest rainfall indicates that part of th
cyclone in which convection is most pronounced. Furthermor
the position of greatest precipitation intensity is intimately con
nected with the continuous redevelopment and direction o
advance of the center of the cyclonic area; the barometri
center of the cyclone moves toward the region of greatest pre
cipitation. The cirrus clouds both in the front and rear of th
larger cyclones have the same general direction as that in whic
the cyclone is traveling, showing that the air currents in whic
the larger cyclones travel extend into the cirrus region. In th
smaller traveling cyclones the cirrus clouds follow more generall
their prevailing directions for the region where observed and t

greater extent move on over the top of the cyclonic area, icating that the smaller cyclone travels in an air current ich does not extend up into the cirrus region. In cyclones ich cease to advance and die out, the cirrus clouds have con- ting directions and are often opposed to the direction in which cyclone has been traveling. In the sixteen cyclones studied re is nothing to indicate the existence of a "dumbbell shaped tex," and there is no spiral outflow of the cirrus from the ber part of the cyclonic area in all directions from the center. broad view of the origin and continuous redevelopment of pical cyclones based on the data assembled is set forth. ures in parenthesis in the text refer to authorities cited in the liography at the end of the paper.

SECTION ONE

Introduction

Cyclonic storms and the phenomena attending them hav received much attention from meteorological students durin the last 75 years, but up to the present time no one has pub lished an intimate study of what has actually occurred at sho intervals of time and space during the passing of the cyclon based on the records made at several stations in different par of the cyclonic area. Algue (10) in his valuable contributio to the subject made 20 years ago gives the detailed observation at one station (Manila) in each of six cyclones. Diagram based on theory showing the ideal spiral inward circulation the air around the cyclonic center are given in the text-book and in some instances synoptic weather charts are reproduce On the weather maps the points of observation are widely sepa rated, the observations are instantaneous, and we do not get sufficient number of records to give us a true conception of th actual wind directions and velocities and the distribution precipitation intensity in the different parts of the cyclone.

When I was authorized by the Chief of the Weather Bure to prosecute the study of the relations of changes in storm tide observed on the coast of the Gulf of Mexico, to the center an movement of hurricanes (2), he instructed me to show als the forces operating in the cyclone which produce the stor tides as they occur in these cyclones.

The storm tides in all cyclones occur on the coast mainl to the right of the line along which the center of the storm h been advancing. The tides appear when the cyclonic cent is 500 to 1000 miles distant in space, and two to four days time, and they rise steadily on coast lines in the right han front of the cyclone, but not to any great extent to the le of the line along which the center of the cyclone has be advancing. The rise in the tide changes position following an change in the direction of movement of the storm area, the ri keeping to the right of the line along which the storm cent was traveling. The winds in the cyclones produce the tides; t

orm spiral inward circulation around the cyclonic center
ne earth's surface, as described and usually shown by dia-
ns in text-books, would not produce the tides as recorded in
ection with these cyclones. With this in mind I began, in
, the collation and study of all the facts recorded in con-
ion with tropical cyclones in the Gulf and South Atlantic
ons, for the purpose of determining whether or not the gen-
y accepted theory of the spiral inward circulation, as applied
inds at the earth's surface in traveling tropical cyclones,
ld stand the test of recorded facts.

ne intensity of precipitation in the different portions of the
one, which unquestionably is governed by the winds in the
n area, has not so far as we can ascertain been studied for
locality free from mountainous influences. Maps showing
rainfall recorded at various points over which a tropical
one has passed do not give any clear idea of rainfall *intensity*
he different parts of the cyclone as related to its moving
er.

ne importance of determining the position of heaviest pre-
ation and the points of localized convection as related to
cyclonic center has recently been emphasized by Shaw (3)
ne following statement:

"We have no very satisfactory information about the dis-
tribution of precipitation in a tropical revolving storm. . . .
Within the area of a cyclonic depression, convection may
be of extreme violence, but it is not by any means uniform.
The localizing of convection points apparently to the line
along which additions to our knowledge might be made with
advantage, and the accurate tracing of the position of rain
areas must be of importance not only for the further in-
vestigation of the polar front, but for many other sides of
meteorological investigations."

this work, by the use of the new method of charting the
nomena of the cyclone, we will show accurately the actual
ipitation intensity in different parts of the cyclone as related
he cyclonic center both in traveling cyclones and in those
h cease to advance.

Previous Studies of Winds in Tropical Cyclones

Results of previous studies, by meteorologists, of the dir
tion of the winds and their incurvature in tropical cyclones
cited below and authorities are quoted briefly *because the pu
lications containing such studies are not generally available
readers.*

Shaw, (1), who has given more attention to the study of wi
in cyclones in general than has any meteorologist since Fer
speaking of the winds in tropical cyclones, says:

> "Possibly gradual incurvature from all sides may ta
> place in the case of tropical hurricanes which move slow
> compared with the winds that occur with them; the or
> of relative magnitude may be taken as ten miles an ho
> for the motion of the center as compared with 100 mi
> an hour for the motion of the hurricane winds. But obs
> vations upon such a point are not very numerous; obser
> tions of any sort during a hurricane are indeed specia
> difficult, and a good deal of our knowledge about them m
> necessarily be by inference."

This statement from a meteorologist so eminent as Sh
emphasizes the fact that heretofore studies to determine wi
takes place within tropical cyclones have been based on a pauc
of observations within the storm itself and that much of
present knowledge regarding the winds, precipitation, pressu
and temperature conditions and changes in tropical cyclo
has been reached by inference.

Birt (5) called attention some seventy years ago, to
effects of the progressive and cyclonic motions on the directi
of the winds in the cyclonic area.

Ferrel (4, 6) almost 50 years ago gave us a tangible the
on the "Resultants of Cyclonic and Progressive Motions," b
although promulgated nearly half a century ago, this theory
not received the attention from meteorological students
writers the importance of the subject merits. The diagramm
representation which Ferrel used to show the combined effe
of a cyclonic circulation advancing through the trade-wind b
of the Caribbean Sea, was probably the first clear statem
indicating the distortion of cyclonic winds resultant from s

mbination of conditions. He pointed out that in the *front* uch an advancing cyclone, the inclination of the winds rds the center would be decreased to a direction almost ght angles to the storm's radius, while in the rear, the re- nt winds would assume a direction more nearly radial, *i.e.,* more directly towards the center of the cyclone. On the -hand side of the line of advance re-enforcement of the velocities with little change in direction, and a similar nution of velocities on the left-hand side, was shown to occur result of the combination of cyclonic and general winds.

me important studies of the wind directions and the force of winds in the different parts of tropical cyclones, in the al localities where they occur, have been made by capable hand investigators on the ground, and all these confirm in neral way Ferrel's theory referred to above.

nes (7) in 1876, prior to the publication of Ferrel's theory, l attention to the fact that the winds *in the rear* of the cal cyclones which he studied showed a great deviation rds the center "not only at a distance from the vortex, even in its vicinity."

discussing the winds in a cyclone in the Arabian Sea, 1881, nbers (8) refers to his Figure 1, Plate XXXVI, and says:

"It will be at once seen by an inspection of this diagram, that although looking from the center, the winds in each octant of the cyclone turn towards the left-hand and generally inward towards the center, they do not make equal angles with the radius of the cyclone in all octants."

gives the wind directions for the different octants, those e left rear quadrant showing an angle with the radius of o 37°, while those in the right front quadrant show an with the radius ranging from 61° to 92°. The winds in ear are inclined towards the center, while the inclination rds the center in the right-hand front quadrant is less than her parts of the cyclone.

ambers (8) also says:

'Another important deviation from perfect symmetry is hat the winds in the northeast, east, southeast, and south

> octants are much stronger than those in the southwest, we northwest, and north octants."

Diagrams illustrating this storm show that the storm cent moved in a direction towards the north-northwest and therefo the octants having the stronger winds fall in the right and tho having weaker winds in the left half of the cyclone.

Doberck (9) in his studies of "Storms in the Eastern Sea calls attention to the deviation of the inclination of the win towards the cyclonic center in the different parts of the cyclon as a result of the prevailing winds in the region and says:

> "The prevailing wind not only carries the center alo with it but combines with the rotary storm, causing t wind in the right-hand (the dangerous) semi-circle to stronger and to blow more nearly around the center th in the left-hand (the manageable) semi-circle, where t wind is more moderate and blows with greater incurvatu towards the center. It also causes the wind to blow straig in towards the center behind the typhoon and to blow mo across the path in front of the center. It also makes t weather heavier after the center is passed than it was wh the center was approaching.
>
> "Less than a half a mile up in the air the incurvatu of the wind towards the center disappears in the average the quadrants, but it still blows in towards the center in t rear. It is really the wind at this altitude that carries t typhoon along, for late in the autumn there are typhoo every year that move along against the NE. monsoon, b we know that the monsoon is at times very shallow a there is southwest wind above it. These typhoons disappe sometimes suddenly; evidently when the NE. monsoon creases in depth and intensity."

In commenting on the influence of the progressive moveme of the storm area on the winds in the cyclone, Algue (10) say

> "The wind directions will be less convergent on the fro side, owing to the progressive movement of the cyclo so that they will more approach a circular form than is t case in the rear. The directions of the wind on the t

sides of the track undergo, owing to the direction of the track and the intensity of the progressive movement, changes which are all the greater the greater the velocity of the cyclone."

umphreys, in speaking of the direction of the winds in ones (11), says:

"From the directions of winds in and about a region of low barometric pressure, as given on synoptic charts, Fig. 98, for instance, it is often, perhaps usually, inferred that cyclonic winds circulate spirally inward and upward and then outward and upward, counter-clockwise in the northern hemisphere, clockwise in the southern, around a storm axis. This indeed is, in general, the course of the winds in tropical cyclones, especially in those that are violent and of small diameter, as the eye of the storm and directions of cloud movements clearly indicate, but it does not apply to extra-tropical cyclones, except, perhaps, to the occasional ones of great violence and small diameter.

"Synoptic weather charts, therefore, show instantaneous wind directions, but not wind-paths. This is because the storm condition itself is moving forward—moving, indeed, with a velocity nearly always comparable to, and at times even faster than, that of the lower winds themselves."

nature we have to deal, as a rule, with traveling cyclones, the *actual* winds as they occur at the earth's surface, and e, in cyclones, are matters of much greater importance than ideal spiral circulation based on theory. The winds in eling cyclones can not be considered properly without taking account the air current in which the cyclone is traveling as influences the winds in the cyclone itself.

arvin (12), in discussing the steady motions of winds within between high and low-pressure areas has referred to this ect and says:

"Cyclones and anticyclones are well-defined cases of wind systems following strongly curved isobars, and the fundamental conditions of steady motions are illustrated in Figure 5. A "HIGH," anticyclone, and a "LOW," cyclone,

are shown in juxtaposition and with closed isobars draw as circles only to simplify the presentation. No suggestio is implied that this diagram represents Nature, except th when, in any actual cases, the gradients, curvature of th isobars, and friction are of the kind shown at any pa ticular point on the diagram; then the velocities of stead motion will be of the nature indicated. Moreover, th motion will be that with reference to the existing pressu system *at the time and place.* It is well known that Hig and Lows travel at considerable velocities in definite dire tions. Therefore, the *actual* motion of the winds *over th ground* will be those compounded from (1) the motio appropriate to the system of curved isobars and (2) th motions of the system as a whole."

After giving equations, Prof. Marvin adds:

"While equations (15) and (17) are basic and funda mental as defining the general steady motions of the a mosphere, *yet diversity of conditions, irregularity of pre sure distribution, changes with time before a state equilibrium is attained, errors in mapping supposed co ditions, and other factors combine to make natural win in particular cases differ widely and frequently from th theoretical deductions herein presented.*"

In a paper issued recently, Shaw (3) in referring to a discu sion by Lord Rayleigh on the subject of "Revolving Fluids the Atmosphere," in which Rayleigh had set forth the vie that if fluid had any vorticity to start with and was carried alo in a current of air the results would be the combination translation with rotation, says:

"I wrote Lord Rayleigh to explain that, although it migh be exemplified in tornadoes and revolving tropical storm and in spite of the fact that tropical revolving storms som times passed continuously from their original condition cyclonic depressions in our areas, I had been unable to fin any evidence of the existence of revolving fluid, such he described in the winds of cyclonic depressions of ou latitudes. He was unconvinced; and on further consider

ion I recognized that in looking for pictorial evidence of revolving fluid I had not taken proper account of the fact (which ought to have been obvious to anyone during the last fifty years) that if the revolving fluid were carried along by a current of air the winds would represent, not simply the rotation, but the combination of translation with rotation.".

rther along in discussing "Examples of Cyclonic Circula- Shaw (3), referring to tropical revolving cyclones, says:

"They begin by traveling with the velocity of the normal current in the region of their origin, about 10 miles per hour, from the east, and pass round the anticyclones of the tropics into the westerly currents of the middle latitudes, where their velocity of travel is increased and their intensity is diminished."

discussing the origin of tropical cyclones, Dr. Harold eys (3) says:

"It may be remarked that it is not necessary to the continuance of a storm that the causes that brought it into being should retain their efficacy. In particular it is not necessary that a strong vertical current should persist. When the revolving column is started, mere inertia will keep it going for a considerable time in spite of friction. This is probably the chief reason why such storms are able to move so far towards the poles when they have once been formed. A revolving storm would naturally be expected to have a motion of translation on this theory. The conditions of its formation require it to start in the Tropics but not at the Equator, since a storm formed at the Equator could acquire no rotation. Thus all such storms start in the regions of the trade winds and the air forming their cores has initially the general motion of the places where they form. It retains this, only changing it in consequence of the widespread pressure difference in the regions through which it passes. Thus these storms have usually velocities of translation not very different from those of the general winds of their surroundings."

Material improvement in the accuracy of weather fore casting can no doubt be obtained when we have more comple knowledge of what actually takes place at short intervals time and space in cyclonic disturbances. Our object in th study is to show, more definitely than has previously been don (a) the distribution of pressure as related to the cyclonic cente (b) the curvature of the isobars at various distances from th storm center, (c) the changes which take place in pressure di tribution as the cyclone advances, (d) the wind directions an velocities as related to the cyclonic center, in the several par of the cyclonic area, at short intervals of time and space, (e) th portions of the cyclonic area in which the convergence of a currents occurs, and (f) the time and place of greatest precipita tion intensity as related to the cyclonic center in tropic cyclones.

Personal Contacts with Tropical Cyclones

During the period, 1900 to 1924, ten tropical cyclones infl enced conditions at the station where the writer has been locate We have been in the various parts of the cyclonic area fro the center outward in nearly every direction, and these person contacts during these 25 years have developed an interest i the characteristics of cyclones and have prompted studies dealin with their more important elements. The cyclones in whic we have had personal experiences include those most notable i the history of this region and are as follows:

1900, September 8; Galveston, where the cyclonic cent moved northward about 20 miles to the west of that plac leaving us in the right-hand half near the line along which th center advanced (13).

1901, August 14-15; New Orleans; when the storm cent curved and moved towards the northeast, leaving us 75 mil to the westward in the left-hand half. In this instance th front of the storm curved over New Orleans (14).

1906, September 26-27; New Orleans; when the storm cent moved northward about 65 miles to the east, leaving us in th left-hand half of the cyclonic area (15).

1909, September 19-21; New Orleans; when the center of th storm moved northward 65 miles to the west of that statio

a slight curvature to the right as it passed by the station, ing us in the right-hand half (16).

15, August 14-22; New Orleans; when the center of the n moved across the Gulf of Mexico towards the northwest, ing us 250 miles to the northeastward in the right-hand (17).

15, September 29-30; New Orleans; when the storm er moved northward about 14 miles west of the station, leav- us in the right-hand half near the line along which the center nced. The storm center curved slightly as it passed the on (18).

16, July 5-6; New Orleans; when the storm center moved hward about 60 miles to the east of the station, leaving us ie left-hand half of the cyclonic area (19).

17, September 26-28; New Orleans; in the front of the line dvance of the center and later in the left-hand half when storm, after moving towards the northwest, curved sharply he northeastward off the mouth of the Mississippi River, ing New Orleans about 130 miles to the northwestward (20).

19, September 11-14; New Orleans; in the right-hand half n the storm moved first toward the northwest and then ward across the Gulf of Mexico, leaving New Orleans 225 s to the northward (21).

20, September 21-22; New Orleans; in the right-hand half n the storm center moved northward about 65 miles to the ward of that place (22).

SECTION TWO—SPECIAL FEATURES

Uniform Nomenclature

Many writers, when describing the characteristics of cyclones use the points of the compass in designating a particular part of the cyclonic area, and the conditions prevailing in that part of the cyclone. If all cyclones traveled in one direction such designations would answer, but cyclones travel towards every point of the compass, and we know that in a cyclone traveling toward the east the characteristics on the north side are much different from the characteristics found on the north side of a cyclone traveling towards the west, in the same hemisphere. For the sake of clearness and to avoid the necessity for the student having to refer to maps in order readily to understand what particular part of the cyclone is being considered, some uniform nomenclature designating the different parts of the cyclones based on their forward movement and the characteristics which are peculiar to the different parts of the cyclone, should be adopted.

Since cyclones travel towards every point of the compass the terms, "front," "rear," "right," or "left" half of the cyclone convey a more intelligent meaning as regards a particular part of the cyclonic area, and the conditions attending the cyclone than the terms "north," "east," "south," and "west," and intermediate points of the compass. Quadrants should be referred to as, "right front" or "right rear" quadrants, and "left rear" or "left front" quadrants to the exclusion of the points of the compass. In all charts of cyclones the front should be designated by an arrow. The above described nomenclature will be used in discussing cyclones in this paper.

Limitations of Observations Made in the Tropics

We recognize that meteorological observations made in the tropics and especially over water areas are preferable for use in the study of tropical cyclones. But observation stations in the tropics are widely scattered and as a rule, notwithstanding the stations may be near sea level, the islands are mountainous near the stations. The mountains on the tropical islands deflect the

ds from the direction which would result in a plains region also modify in a variable degree the velocity of the wind. thermore it is not possible at such stations to distinguish orographic precipitation from that which results from the vergence of the winds in the cyclone.

eports from ships at sea are desirable, but it is a well known that ships avoid hurricanes and consequently the observas made by ships in a hurricane are few in number and ly scattered. The location of the ship's position cannot be rately determined because of the cloudiness attending the icane. Masters of ships who have gone through hurricanes e told me that when they succeeded in correctly locating r position after having been through a storm they often d they were 50 or more miles from their estimated position. tain Lecky, in "Wrinkles on Practical Navigation," comting on this point, says:

"Owing to the fact that a ship is not a fixed observatory, and that the determination of the wind force on a steamship is far from easy, confusion can only result from efforts at a measure of the angle of indraught by means of observations taken on board ships under the influences of a hurricane when there are other matters to be safeguarded." . . .

And he further adds: "Hurricanes in low latitudes are of small radius and great intensity, an unknown sea surface and lack of ship's position by observation are quite common on such occasions; and consequently conclusions based on such uncertain data are worse than useless—they are misleading."

have been closely identified with marine meteorological for 37 years, especially with ships whose courses were in regions traversed by tropical hurricanes and have been on d ship in an intense hurricane. The masters and officers ips are conscientious and careful in this work, but due to itions existing in a hurricane they have their limitations. e from the difficulty of determining the locations of vessels rricanes, the great value of reports from vessels should not verlooked. For purposes of forecasting and the general y of storms of all kinds at sea, as well as of oceanic cli-

matology, the services rendered by ship masters can not b overestimated.

Climatic Characteristics of the Gulf Coast Region

The Gulf and South Atlantic coasts, on account of the larg extent of coastal plain with no elevated areas, appear to furnis the most suitable conditions anywhere to be found for the stud of the winds and the causes of precipitation in tropical cyclone

Well-defined tropical climatic conditions extend far north i the Gulf region during the hurricane season. Here, during th summer months, a well-defined monsoonal condition (4, 23, 41 prevails, a continuation of the easterly trade winds curving ove the Gulf and coming in on the coast of the Gulf of Mexico fro a southeasterly to southerly direction with an average velocit of 10 to 12 miles per hour during July, August, and September This warm air current, nearly saturated with moisture, is a times approximately 1000 miles wide and two to sometime five miles deep. Kite observations (24) at Groesbeck, Texas 160 miles inland from the coast, and Broken Arrow, Oklahoma 500 miles inland, taken in conjunction with directions of cirru clouds farther to the east during the passage of tropical cyclone show that the winds over this region at times have a depth o between two and three miles, and in some cases the altitude i still greater before the prevailing westerly drift of the atmos phere overcomes the monsoonal winds.

The importance of the monsoonal wind as a factor in the climatic control of this region must receive careful attentio in the study of the subject under consideration. The prevailing moist, southerly winds intensify the tropical conditions a regards temperature and moisture which prevail during th summer months over the Gulf Coast region. This applies par ticularly to that area lying between longitude 87° and 102 with an elevation below 500 feet.

Changes with Latitude

In studying tropical cyclones during their passage throug extra-tropical latitudes, the question naturally arises; To wha extent do they retain their tropical characteristics? While th majority of these storms originate south of Lat. 23° 30′, th

ses they follow, and frequently their periods of greatest nsity, are found well outside of the intertropical region, n several hundred miles north of the Tropic of Cancer. r passing outside the tropics, these storms travel for long nces through latitudes which *at that season,* have tropical atic conditions, and while in such regions it may be inferred they retain their tropical characteristics, *except as slowly ified by the effects of increasing latitude.*

ne influence of latitude up to 40° is not very great. Hum-ys (11) gives the values of deflective tendency, due to the n's rotation, in degrees per hour at different latitudes as ws:

tude (deg.)	15	20	25	30	35	40
ective tendency (deg.)	3.89	5.14	6.36	7.53	8.63	9.68

se represent the values of the rate of change of wind direc-s over the earth's surface, due solely to the earth's rotation ming no friction, visosity, or disturbing pressure gradient. s evident that the deflective influence will be diminished ne actual case of a tropical cyclone due to the presence of causes which are assumed, in the above table, not to be ent. The latitude effect in this region being small, only t one degree of increase in deflective change in each 5° of ude, it may be safely assumed that except for a tendency to den the cyclonic field there will be no material change in characteristics of a tropical cyclone moving from 20 to 35 ees latitude through a region having tropical climatic acteristics.

RLY WIND DIRECTION, VELOCITY, AND PRECIPITATION, AS ATED TO THE CENTER AND MOVEMENT OF TROPICAL CYCLONES

ne United States Weather Bureau has very complete records self-recording instruments at from two to six stations in the s traversed by sixteen tropical cyclones under consideration h have moved in over the Gulf and South Atlantic regions ng the last 25 years. The wind is recorded in miles per hour, the directions for each minute; the precipitation is recorded undredths of an inch, showing the time and rate of fall so the intensity can easily be determined. The directions

of upper air movements are shown by eye observations of clou movements. Much valuable knowledge can be obtained b charting and studying the hourly wind velocity and directio cloud directions, and the hourly precipitation at individual sta tions during the passage of a tropical cyclone. In the presen study these data have been assembled and charted so as t show in detail what occurred at the individual stations as th cyclone advanced. In this manner we find out exactly wha occurs at stations while in front and also in the rear, of th cyclone.

Cyclones seldom advance along straight lines, therefore th path followed by the cyclonic center, and its hourly movemen are first determined and charted. In determining the path alon which a given cyclonic center advanced and the time the cyclon center passed a given place, the records of the time of th occurrence of the lowest pressure and the wind shift at statio in the line of advance of the center have been supplemented b the use of the time of the occurrence of the lowest pressure a stations within the cyclonic area on either side of the line alon which the center advanced. These have been used in the manne we have previously illustrated in the Monthly Weather Revie (22). The location of the storm center at hours other tha those determined as above has been interpolated, using all in formation available.

Method Used in Charting

The method followed in charting the hourly wind and precipi tation and the cloud directions as related to the cyclonic cente for stations in the cyclonic area, is explained as follows: Th path of each cyclone has been carefully determined and charte in the manner described above on a map drawn to scale; th stations in the storm area are located on this map in their prope geographical positions as related to the path along which th cyclonic center traveled. The points of the compass are care fully drawn for each station within the cyclonic area as a guid in entering the successive wind and cloud directions, recorde as the cyclone advanced.

The hourly wind and cloud directions, the wind velocity and the precipitation are charted on a sheet of transparent pape

cing paper) using the same scale as the map on which are
vn the path of the cyclone and the positions of the stations
ne cyclonic area. This sheet of paper is divided into halves
quarters by two straight lines intersecting each other at
t angles in the center of the sheet. The direction of the
ance of the cyclonic area is represented on the transparent
er by the vertical line on the sheet, terminated by an arrow
l at the top of the line. The line terminating with an arrow
l divides the chart of the cyclonic area into right and left
es, while the transverse line divides the cyclonic area into
t and rear halves, with resulting quadrants. The map on
ch the path of the cyclonic center is plotted and on which
stations within the cyclonic area are shown is used to repre-
the earth's surface, while the sheet of transparent paper
ded as above described is used to represent the moving
onic area.

ne positions of the stations of observation within the cyclonic
, as related to the position of the cyclonic center, are con-
ally changing because the storm is advancing over the earth's
ace, frequently along a curved line. The direction towards
ch a curving cyclonic center advances must be shown for
hour in order that the entries of wind and precipitation
appear in their proper positions as related to the cyclonic
er, represented on the movable sheet of transparent paper
he intersection of the cross lines.

ne correct entry of the data recorded during the passage of
cyclone is accomplished in the following manner. The
rsection of the cross lines on the sheet represented as the
onic area is placed over the first hour on the path of the
one, for which entry is to be made, with the arrow-line
ting to the front and tangent to the path of the cyclone.
sheet representing the cyclonic area is then advanced step
tep to each successive hour along the plotted path of the
one. When the intersection of the cross lines is placed
nst any hourly position on the path of the cyclone and the
with the arrow pointing to the front is tangent to the curve
ne path of the cyclonic center at that hour, the arrow then
cates the direction in which the cyclonic center was ad-
cing at that moment, and the entries made on the trans-

parent sheet for the corresponding hour show their prop positions and directions as related to the cyclonic center at t intersection of the cross lines.

As an illustration take the tropical cyclone of October 23-2 1921. The path and hourly progress of this cyclonic area a shown on Figure 1. The positions of the outer ends of t hourly lines intersecting the line of advance of the storm cent at right angles are also shown some distance to the left of t path by dotted points corresponding to each hourly position the center of the storm. This serves as an aid in entering a checking the data for any hour.

The movable cyclonic area representing the cyclone of Octob 23-27, 1921, and the hourly winds and precipitation are chart in Figure 35. This chart was prepared in conjunction wi Figure 1 and will be used in explaining the manner of procedu in preparing all charts.

Take the chart Figure 35 and place the intersection of t cross lines against the point indicating the storm center 4 a. m., October 23d, on Figure 1, the arrowed line pointing the direction in which the cyclone was traveling and tange to the path of the cyclonic center; the first entry in the fro of the cyclone is then made for Key West, Fla., wind velocity miles per hour with the direction as shown on the chart and inch of precipitation (the entries for Key West are for each t hours), the chart is then advanced so that the intersection the cross lines, representing the cyclonic center, is against t point for 6 a. m., the arrow-line tangent to the path, when t second entry for Key West is made, and so on for other hou The first entry at Tampa, Fla., is at 5 a. m., October 23d. T first entry for Jacksonville, Fla., is made when the intersection the cross lines is against 1 a. m., October 24th; Savannah, G midnight of the 24th-25th; and Charleston, S. C., at 6 a. m October 25th, as these hours mark the entrance of the respecti stations into the cyclonic field.

Commencing at 4 a. m., October 23d, for the first entry, t intersection of the cross lines representing the center of t cyclonic area is advanced to each successive hourly positio keeping the line with the arrow pointing to the front and tange to the curved path of the cyclonic center, and the entries of t

and cloud directions, wind velocity, and precipitation, are hourly for each of the five stations within the cyclonic area the time the stations come into the front until the stations out through the rear of the cyclonic area. The last entry ey West, Fla., is made when the intersection of the cross is against midnight of October 25-26th; Tampa, Fla., at m., October 26th; Jacksonville, Fla., at 9 p. m., October and Savannah, Ga., and Charleston, S. C., when the inter-n of the cross lines of the cyclonic center is against mid- of October 26-27th, 1921.

Meteorological Conditions in Individual Cyclones

urly records of pressure, temperature, precipitation, wind ion and velocity, and the kind and direction of the clouds ved at from two to eight first-order meteorological stations n the cyclone together with supplemental data are given xteen tropical cyclones in Tables I to XVIII. The distribu- of these elements in the several cyclones as related to the nic center and the direction in which the cyclone was travel- re shown in Figures 2 to 53.

der the method of charting previously described the hourly direction and velocity, the direction of the clouds observed, the hourly precipitation at the several stations in the nic area are shown for each station for all the cyclones in the records are complete; the entries are made on the s in the exact positions, as related to the intersection of oss lines on the chart, that the stations bore to the cyclonic r at the hour of entry, from the time the front of the cyclonic reached the station until the time the station was left in ear of the cyclone. The light arrows appearing every hour ind directions, the figures to the left of the wind directions he wind velocities, and the figures to the right of the directions are the hourly precipitation amounts; the arrows represent the directions of the lower clouds and roken arrows represent the directions of the upper clouds rus types. Charted in this manner the data show the ions of wind and precipitation, at short intervals of time pace, in the different parts of the cyclonic area. The wind ions are thus shown not only at the earth's surface, but

also in the cloud region. The characteristics of the cyclone as brought out in the tables and illustrations, are discussed fi for the individual cyclone and then collectively for cyclones similar sizes and types combined.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIO —*Cline.*

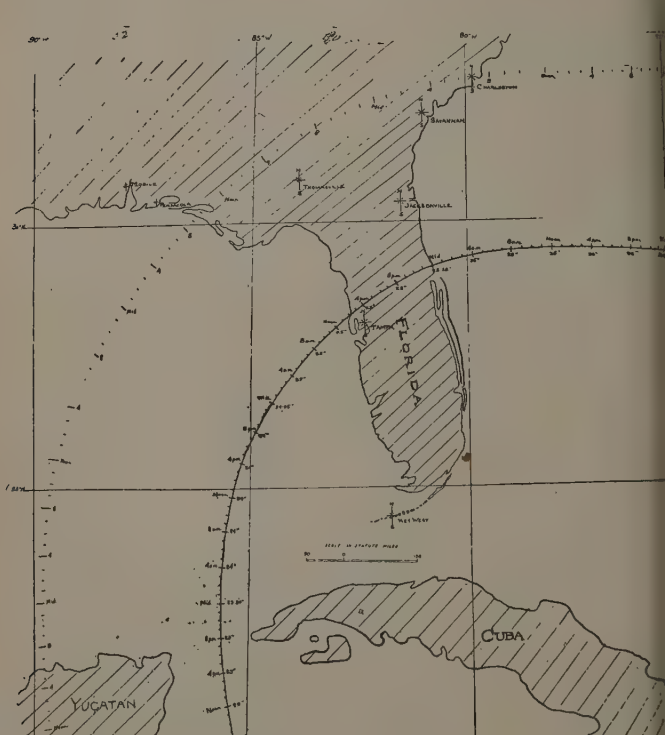


Figure 1. Path of tropical cyclone of October 23-27, 1921, and locations of sta in their relations to the movement of the cyclonic center. Used in illustratin method followed in charting the data around the cyclonic center.

SECTION THREE—DATA IN CYCLONES

I

Tropical Cyclone of September 6 to 9, 1900

ıe records of meteorological conditions during the passage e tropical cyclone of September 6 to 9, 1900, (13) are given able I. The path followed by this cyclone is marked "A" igure 2. Galveston was the only station near the center of cyclone and the wind and precipitation records for that on are incomplete, the loss of record resulting from damage struments by the wind. For this reason no chart of winds precipitation in this cyclone has been made.

TABLE I

TROPICAL CYCLONE ON THE WEST GULF COAST, SEPTEMBER 6TH TO 8TH, 1900
90th Meridian Time

Corpus Christi, Texas.
Latitude 37° 49′ N. Longitude 97° 25′ W. To the left of the line followed by the center of the cyclone, 175 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
7th							
3 p.m.				n.	14	cu.	n.
4 p.m.				n.	13		
5 p.m.				n.	11		
6 p.m.				n.	11		
7 p.m.				n.	10	a. st.	e.
8 p.m.				n.	8	a. cu.	e.
9 p.m.				....	8		
10 p.m.				....	8		
11 p.m.				....	12		
12 mid.				....	12		
8th							
1 a.m.				....	13		
2 a.m.				....	12		
3 a.m.				....	11		
4 a.m.				....	11		
5 a.m.				....	13		
6 a.m.				....	12		
7 a.m.				nw.	18	ci. cu.	e.

Galveston, Texas.
Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 20 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
7th							
4 p.m.	29.71	90		n.	13		
5 p.m.	29.70	91		n.	12		
6 p.m.	29.69	90		n.	11		
7 p.m.	29.70	90		n.	11	st. cu.	ne.
8 p.m.	29.70	88		n.	11		
9 p.m.	29.70	88		n.	10		
10 p.m.	29.71	87		ne.	12		
11 p.m.	29.72	86		ne.	13		
12 mid.	29.72	85		n.	16		
8th							
1 a.m.	29.69	84		n.	15		
2 a.m.	29.67	84		n.	15		
3 a.m.	29.65	84		n.	15		
4 a.m.	29.64	83		n.	16		
5 a.m.	29.62	83		n.	17		
6 a.m.	29.60	82		n.	17		
7 a.m.	29.57	82		ne.	19	st.	n.
8 a.m.	29.55	81		n.	22		

Hourly Precipitation Record Not Complete

New Orleans, La.
Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 235 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
6th						ci.	se.
12 noon	29.97	86	0	ne.	16	cu.	n.
1 p.m.	29.93	86	0	n.	16	ci. st	se
2 p.m.	29.91	88	0	n.	15	cu.	ne
3 p.m.	29.87	90	0	ne.	13		
4 p.m.	29.86	90	0	ne.	15		
5 p.m.	29.83	91	0	ne.	15		
6 p.m.	29.82	91	0	ne.	14		
7 p.m.	29.80	88	0	ne.	14	a st.	sw
8 p.m.	29.79	86	0	ne.	12		
9 p.m.	29.80	85	0	n.	12		
10 p.m.	29.79	85	0	ne.	12		
11 p.m.	29.79	84	0	n.	13		
12 mid.	29.78	84	0	ne.	15		
7th							
1 a.m.	29.77	83	0	ne.	15		
2 a.m.	29.75	83	0	ne.	18		
3 a.m.	29.74	82	0	ne.	19		
4 a.m.	29.71	82	0	ne.	20		

DATA AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
8th							
10 a.m.							
11 a.m.							
12 noon							
1 p.m.							
2 p.m.							
3 p.m.							
4 p.m.							
5 p.m.							
6 p.m.							
7 p.m.							
8 p.m.							
9 p.m.							
10 p.m.							
11 p.m.							
12 mid.							

To the left of the line followed by the center of the cyclone, 175 miles.

DATA AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
8th					16		
10 a.m.				nw.			
11 a.m.				nw.	15	a. st.	e.
12 noon				nw.	18		
1 p.m.				nw.	20		
2 p.m.				nw.	20		
3 p.m.				nw.	22		
4 p.m.				nw.	17		
5 p.m.				nw.	20		
6 p.m.				nw.	20		
7 p.m.				nw.	25	st.	
8 p.m.				nw.	23		
9 p.m.				....	25		
10 p.m.				....	24		
11 p.m.				....	21		
12 mid.				....	20		

To the right of the line followed by the center of the cyclone, 20 miles.

DATA AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
8th	29.52	79	Hourly Precipitation Record Not Complete	n.	25	nb.	ne.
11 a.m.							
12 noon	29.48	74		n.	27		
1 p.m.	29.41	74		n.	31		
2 p.m.	29.37	74		n.	35	nb.	ne.
3 p.m.	29.31	75		n.	35		
4 p.m.	29.21	75		ne.	43		
5 p.m.	29.13	75		ne.	46		
6 p.m.	28.94	75		ne.	60	nb.	ne.
7 p.m.	28.76	75		ne.	—	—	
8 p.m.	28.55	75		ne.	—	—	
8.30 pm	28.48	—		Center	—	Passed	
9 p.m.	28.51	76		e.	—		
10 p.m.	28.76	76		e.	—		
11 p.m.	28.93	76		se.	—		
12 mid.	29.00	76		s.	—		
9th							
1 a.m.	29.10	76					
2 a.m.	29.21	76					
3 a.m.	29.27	77					
4 a.m.	29.31	76					

To the right of the line followed by the center of the cyclone, 235 miles.

DATA AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
7th							
7 a.m.	29.73	80	0	ne.	20	ci. st.	se.
8 a.m.	29.74	80	0	ne.		st. cu.	ne.
9 a.m.	29.75	81	0	ne.	21		
10 a.m.	29.74	81	0	ne.	26		
11 a.m.	29.73	82	0	ne.	27		
12 noon	29.72	83	0	ne.	26	st. cu.	ne.
1 p.m.	29.71	84	T.	ne.	31		
2 p.m.	29.68	86	0	ne.	28		
3 p.m.	29.66	84	0	ne.	28	st. cu.	ne.
4 p.m.	29.65	83	0	ne.	29		
5 p.m.	29.65	83	0	ne.	28		
6 p.m.	29.65	82	0	ne.	30		
7 p.m.	29.66	82	0	ne.	20		
8 p.m.	29.67	81	.03	ne.	29	nb.	ne.
9 p.m.	29.68	79	.61	ne.	26		
10 p.m.	29.70	80	T.	ne.	24		
11 p.m.	29.70	79	.02	ne.	24		
12 mid.	29.69	80	T.	ne.	23		
8th					20		
1 a.m.	29.70	80	T.	ne.	15		

TABLE I

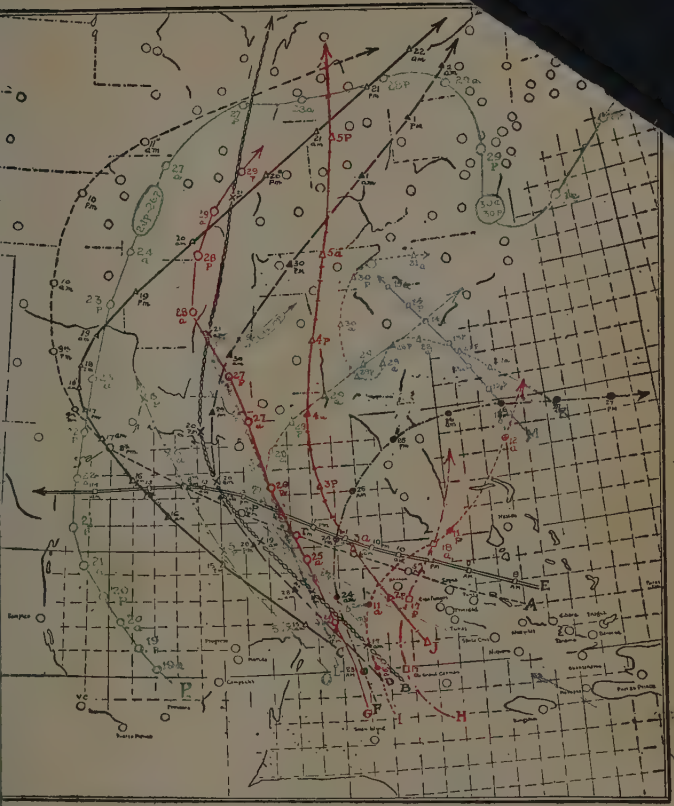
TROPICAL CYCLONE ON THE WEST GULF COAST, SEPTEMBER 6TH TO 8TH, 1900
90th Meridian Time

Corpus Christi, Texas. Latitude 37° 49′ N. Longitude 97° 25′ W. To the left of the line followed by the center of the cyclone, 175 miles.								Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 20 miles.								New Orleans, La. Latitude 29° 58′ W. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 235 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction							Kind	Direction
								9th								8th							
								5 a.m.	29.34	79						2 a.m.	29.68	79	.15	e.	15		
								6 a.m.	29.36	80						3 a.m.	29.68	80	.01	e.	13		
								7 a.m.	29.42	80				st.	s.	4 a.m.	29.68	81	T.	e.	13		
								8 a.m.	29.46	81						5 a.m.	29.69	81	T.	ne.	13		
								9 a.m.	29.50	83						6 a.m.	29.70	74	.46	se.	15		
								10 a.m.	29.53	85						7 a.m.	29.72	77	0	se.	18	st. cu.	se.
								11 a.m.	29.56	85						8 a.m.	29.74	80	0	e.	18		
								12 noon	29.58	86						9 a.m.	29.75	78	.10	se.	18		
								1 p.m.	29.60	82						10 a.m.	29.78	74	.42	se.	23		
								2 p.m.	29.61	79						11 a.m.	29.80	76	0	se.	25	a. st. st.	? se.
								3 p.m.	29.61	83						12 noon	29.81	83	0	se.	26		
								4 p.m.	29.61	85						1 p.m.	29.82	83	0	se.	29		
								5 p.m.	29.62	87						2 p.m.	29.82	84	0	se.	28		
								6 p.m.	29.63	88						3 p.m.	29.82	83	T.	se.	28		
								7 p.m.	29.64	85				ci.	se.	4 p.m.	29.81	82	.02	se.	24		
								8 p.m.	29.66	83				a. st.	se.	5 p.m.	29.81	82	0	se.	20		

Hourly Precipitation Record Not Complete

Record Lost After 12 Midnight

Record Lost After 6 p. m.



gure 2. Tropical cyclones in the Gulf and South Atlantic regions, discussed
his book, grouped according to sizes and types.
rger cyclones which continued to travel on moving inland: "A" September
1900; "B" September 17-21, 1909; "C" August 15-22, 1915; "D" September
), 1915; "E" September 8-15, 1919; "F" October 23-27, 1921.
naller cyclones which continued to travel on moving inland: "G" September
), 1906; "H" October 17-19, 1906; "I" October 10-13, 1909; "J" September
1915.
opical cyclones which ceased to advance on moving inland: "K" August
, 1911; "L" July 3-10, 1916; "M" July 12-16, 1916.
opical cyclones which owing to irregular movements do not fall into either
ie preceding classes: "N" September 27-29, 1917; "O" August 5-6, 1918; "P"
19-30, 1921.
orm tracks do not extend back to point of origin.

II

Tropical Cyclone of September 26-27, 1906

Detailed meteorological data recorded during the passage of e tropical cyclone of September 26-28, 1906 (15), are given Table II. The winds, precipitation, and clouds, as related to e movement of the cyclonic center, are given in Figure 3 for ch hour during the passage of the cyclone over Pensacola and obile, in the right half, and New Orleans in the left half of e cyclonic area. This cyclone moved through the Yucatan annel into the Gulf of Mexico near the western end of Cuba, vanced towards a point little west of north, and moved inland the Mississippi Coast, as indicated by the storm path marked " on Figure 2.

When this cyclone moved inland no marked intensity ap- ared outside the isobar of 29.7 inches, and in this instance the meter of the cyclone is considered as coming within this bar; the diameter of the cyclone on the line dividing it into nt and rear halves was 450 miles and on the line dividing into right and left halves was 400 miles. The isobars spread t somewhat, showing a bulging on the left side.

The wind directions in the right rear quadrant of the cyclonic a were of the same general direction as that in which the clone was traveling; the winds in the rightfront quadrant ow about the same inclination towards the center both at obile and Pensacola; the winds moved around through the t front quadrant into the left rear quadrant where the in- nation towards the center increased. The wind velocity at obile dropped from 46 miles at the time of the passage of the nter to 28 miles four hours later, while at Pensacola, only a ort distance in the rear and to the right of Mobile, farther ay from the cyclonic center, the wind continued above 30 les per hour for 24 hours after the passage of the cyclonic nter; during the greater part of this time the wind at Mobile s only 8 to 20 miles per hour.

The directions of the lower clouds were generally the same as e surface winds except that in the right front quadrant the

lower clouds more than 150 miles in front of the center had direction different from the wind and were inclined somewha outward from the center, and in the left rear quadrant th clouds 100 miles to the rear of the center shifted direction an turned more toward the center three hours earlier than th surface winds shifted to the same direction.

Precipitation commenced in front of the cyclonic area whe the storm center was distant 18 hours in time and about 17 miles in space. A decided increase in precipitation intensit commenced 100 miles in front of and fourteen hours before th passage of the storm center, with the greatest intensity occurrin about two hours before the passage of the center. The precipi tation after the passage of the line dividing the cyclone int front and rear halves was very small as compared to the amoun in front of that line. The total precipitation at Pensacola Fla., to the right, was 3.25 inches, while at New Orleans, th same distance to the left of the center, it amounted to only 1.2 inches. There was a secondary rainfall at Pensacola, 150 mile in the rear of the center, almost outside the cyclonic area, an not used in the Pensacola total.

New Orleans, La. Latitude 29° 58′ N. Longitude 90° 04′ W. To the left of the line followed by the center of the cyclone, 65 miles.								Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the right of the line followed by the center of the cyclone, 50 miles.								Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 85 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction							Kind	Direction
26th								26th								26th							
10 a.m.	29.85	75	T.	ne.	15			8 a.m.		76	0	ne.	14	st.	e.	10 a.m.	29.78	79	T.	ne.	24		
11 a.m.	29.83	77	0	ne.	16	st. cu.	ne.	9 a.m.		78	0	ne.	14			11 a.m.	29.78	79	T.	ne.	25	nb.	ne.
12 noon	29.81	78	0	ne.	18			10 a.m.	29.76	80	0	ne.	14			12 noon	29.75	76	.01	ne.	23		
1 p.m.	29.77	79	0	ne.	18	a. st.	ne.	11 a.m.	29.74	80	0	ne.	13	st.	e.	1 p.m.	29.71	76	.03	ne.	23	nb.	ne.
2 p.m.	29.75	81	0	ne.	19			12 noon	29.73	80	0	ne.	13			2 p.m.	29.69	75	.02	ne.	25		
3 p.m.	29.74	81	0	n.	20			1 p.m.	29.72	79	T.	ne.	15	nb.	e.	3 p.m.	29.66	75	T.	ne.	27	nb.	ne.
4 p.m.	29.73	81	0	ne.	20			2 p.m.	29.70	78	.06	ne.	14			4 p.m.	29.62	74	.03	ne.	29		
5 p.m.	29.72	80	0	ne.	23			3 p.m.	29.68	76	.01	ne.	14			5 p.m.	29.62	74	.03	ne.	31		
6 p.m.	29.70	80	T.	ne.	25			4 p.m.	29.66	75	.03	n.	16			6 p.m.	29.59	73	.03	ne.	33		
7 p.m.	29.68	78	T.	ne.	29	st. cu.	ne.	5 p.m.	29.66	74	.02	n.	19			7 p.m.	29.56	72	.05	ne.	36	nb.	ne.
8 p.m.	29.68	77	0	n.	28			6 p.m.	29.65	74	.02	n.	21			8 p.m.	29.52	72	.02	ne.	40		
9 p.m.	29.67	73	.05	ne.	28			7 p.m.	29.63	74	.02	n.	24	nb.	ne.	9 p.m.	29.50	73	.04	ne.	46		
10 p.m.	29.65	72	.06	n.	26			8 p.m.	29.62	74	.12	ne.	23			10 p.m.	29.47	71	.06	ne.	44		
11 p.m.	29.62	71	.05	n.	26			9 p.m.	29.57	72	.12	ne.	26			11 p.m.	29.42	72	.11	ne.	43		
12 mid.	29.59	74	.03	n.	32			10 p.m.	29.56	70	.18	ne.	26			12 mid.	29.35	72	.17	ne.	44		
27th								11 p.m.	29.51	73	.10	ne.	27			27th							
1 a.m.	29.54	75	T.	n.	35			12 mid.	29.48	73	.05	ne.	31			1 a.m.	29.31	73	.81	ne.	45		

TABLE II

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 26 TO 28, 1906
90th Meridian Time

New Orleans, La. Latitude 29° 58′ N. Longitude 90° 04′ W. To the left of the line followed by the center of the cyclone, 65 miles.								Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the right of the line followed by the center of the cyclone, 50 miles.								Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 85 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction							Kind	Direction
27th								27th								27th							
2 a.m.	29.49	75	.01	n.	37			1 a.m.	29.40	72	.31	ne.	32			2 a.m.	29.29	75	.46	e.	64		
3 a.m.	29.44	73	.03	n.	39			2 a.m.	29.32	71	.49	ne.	33			3 a.m.	29.27	75	.47	e.	68		
4 a.m.	29.40	70	.41	n.	40			3 a.m.	29.27	71	.55	ne.	31			4 a.m.	29.18	76	.13	e.	74		
5 a.m.	29.38	70	.07	n.	41			4 a.m.	29.19	72	.54	ne.	34			5 a.m.	29.17	76	.35	se.	68	Center	
6 a.m.	29.34	72	.21	n.	38			5 a.m.	29.10	73	.57	ne.	36	Center		6 a.m.	29.19	76	.38	se.	67	Passed	
7 a.m.	29.27	72	.03	nw.	38	nb.	nw.	6 a.m.	29.00	73	1.34	ne.	46	Passed		7 a.m.	29.24	77	.06	se.	72	nb.	se.
8 a.m.	29.22	72	.09	nw.	40			7 a.m.	28.84	73	.46	e.	42	nb.	se.	8 a.m.	29.31	75	T.	se.	62		
8:15 am	29.15			Center		Passed		8 a.m.	28.90	74	.54	e.	43			9 a.m.	29.35	78	0	se.	58		
9 a.m.	29.16	71	.02	nw.	39			9 a.m.	29.00	73	.19	se.	39			10 a.m.	29.39	80	0	se.	55		
10 a.m.	29.16	71	.04	nw.	38			10 a.m.	29.12	72	.23	se.	28			11 a.m.	29.41	81	0	se.	52		
11 a.m.	29.18	72	.03	nw.	30			11 a.m.	29.18	79	.17	se.	27			12 noon	29.45	80	0	se.	53		
12 noon	29.20	70	.04	w.	27	nb.	w.	12 noon	29.25	75	.06	se.	21			1 p.m.	29.45	82	0	se.	51		
1 p.m.	29.25	71	.07	w.	25	nb.	w.	1 p.m.	29.27	76	.05	se.	21			2 p.m.	29.45	79	.01	se.	47		
2 p.m.	29.28	71	.03	w.	24			2 p.m.	29.29	76	.01	se.	15			3 p.m.	29.46	80	T.	s.	46		
3 p.m.	29.31	72	T.	w.	25			3 p.m.	29.31	76	.03	se.	15			4 p.m.	29.49	75	0	s.	44		
4 p.m.	29.34	73	T.	sw.	23			4 p.m.	29.35	75	.03	se.	14			5 p.m.	29.51	77	0	s.	42		
																6 p.m.	29.53	74	0	s.	41		

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 26 TO 28, 1906

TABLE II

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
New Orleans, La. Latitude 29° 58′ N. Longitude 90° 04′ W. To the left of the line followed by the center of the cyclone, 65 miles.							
27th							
6 p.m.	29.41	72	0	sw.	21		
7 p.m.	29.44	72	0	sw.	21	st.	sw.
8 p.m.	29.47	71	0	sw.	22		
9 p.m.	29.50	71	0	sw.	17		
10 p.m.	29.55	72	0	sw.	15		
11 p.m.	29.56	72	0	sw.	14		
12 mid.	29.57	72	0	sw.	11		
28th							
1 a.m.	29.61	71	0	sw.	13		
Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the right of the line followed by the center of the cyclone, 50 miles.							
27th							
6 p.m.	29.41	75	.01	se.	14		
7 p.m.	29.45	75	T.	se.	12	nb.	se.
8 p.m.	29.47	76	T.	se.	10		
9 p.m.	29.51	74	0	se.	9		
10 p.m.	29.55	74	0	se.	10		
11 p.m.	29.55	75	0	s.	9		
12 mid.	29.58	75	0	s.	9		
Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 85 miles.							
27th							
7 p.m.	29.55	78	0	s.	38		
8 p.m.	29.59	78	0	s.	39		
9 p.m.	29.63	77	0	s.	41		
10 p.m.	29.65	74	.04	s.	40		
11 p.m.	29.65	77	.45	s.	35		
12 mid.	29.61	79	.20	s.	36		
28th							
1 a.m.	29.69	74	0	s.	33		
2 a.m.	29.69	74	0	s.	34		
3 a.m.	29.70	79	0	sw.	34		
4 a.m.	29.72	78	0	s.	32		
5 a.m.	29.75	79	0	s.	31		
6 a.m.	29.78	79	0	s.	28		

Tropical Cyclones in the Gulf and South Atlantic Region —*Cline.*

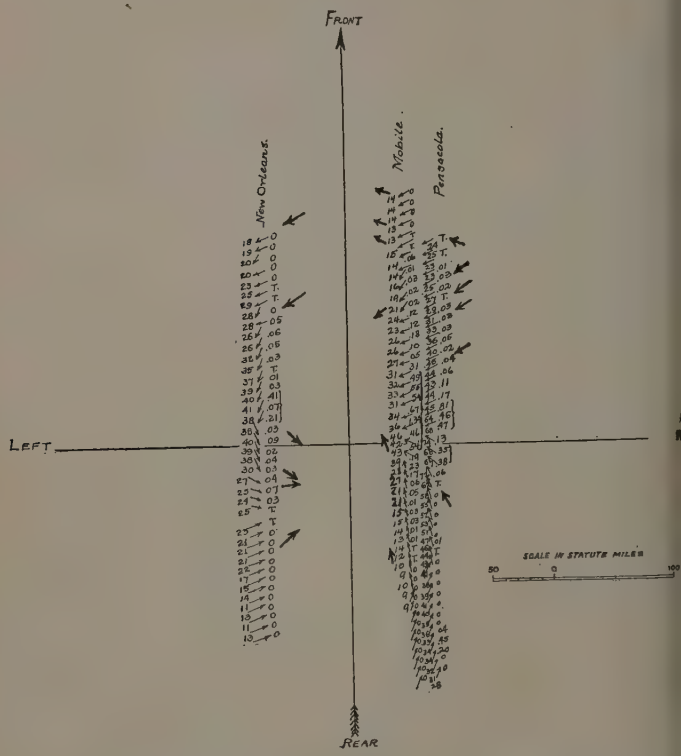


Figure 3. Records made during the passage of the tropical cyclone, Septem 26-27, 1906. Intersection of the cross lines represents the center of the cycl Points of the small regular arrows rest on positions of stations at the time the rec were made. Figures on the left of the arrows are wind velocities in miles per h figures on the right of the arrows are the hourly precipitation measured to hundre of an inch. Brackets show the greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types This cyclone falls in the group of the smaller traveling cyclones.

III

Tropical Cyclone of October 17-19, 1906

Hourly meteorological data recorded during the passage of tropical cyclone through the Florida Straits, October 17-19, 6, (25) are given in Table III. Owing to the sparsity of erving stations complete isobaric maps are not obtainable, isobars appear mainly circular while over that region, with diameter of the cyclone about 350 miles. The path followed the center of this cyclone is designated by the letter "H," ure 2.

Winds and precipitation in their relation to the position and ection of movement of the cyclonic center during the passage his cyclone are charted in Figure 4. The stations within this lone were Jupiter and Key West, Fla., 30 and 50 miles re-ctively to the left of the line followed by the center, which ved across the Florida Straits and out into the Atlantic Ocean. Key West, 50 miles to the left of the center, the lower uds shifted direction, as the center approached, eight hours ore the surface wind shifted to the same direction; but at iter, nearer the line along which the center was advancing, surface wind shifted direction as the center approached five rs before the lower clouds shifted to the same direction.

The total precipitation at Key West before the passage of the lonic center was 2.74 inches, and only .04 of an inch occurred r the passage of the storm center. At Jupiter, 3.13 inches precipitation occurred before and 1.95 inches after the passage the storm center. This cyclone ceased traveling soon after center passed Jupiter and it gradually filled up and died out.

TROPICAL CYCLONE IN THE FLORIDA STRAITS, OCTOBER 17 TO 19, 1906

TABLE III 75th Meridian Time

Key West, Florida. Latitude 24° 33′ N. Longitude 81° 48′ W. To the left of the line followed by the center of the cyclone, 50 miles.								Jupiter, Florida. Latitude 26° 57′ N. Longitude 80° 07′ W To the left of the line followed by th center of the cyclone, 30 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUD	
						Kind	Direction							Kind	Direction
17th								17th							
1 a.m.	29.72	73	0	ne.	8			10 a.m.	29.78	81	0	w.	4		
2 a.m.	29.72	72	0	ne.	6			11 a.m.	29.74	82	0	e.	7		
3 a.m.	29.72	70	0	ne.	5			12 noon	29.72	81	0	se.	7		
4 a.m.	29.74	71	0	ne.	6			1 p.m.	29.71	80	0	e.	9	ci.	w.
5 a.m.	29.74	72	0	e.	7			2 p.m.	29.72	81	0	se.	8	st. cu.	se.
6 a.m.	29.73	73	0	e.	8			3 p.m.	29.71	78	0	se.	9		
7 a.m.	29.73	77	0	e.	6			4 p.m.	29.72	77	0	se.	7		
8 a.m.	29.73	78	0	e.	12	a. st.	w.	5 p.m.	29.73	77	0	se.	7		
9 a.m.	29.70	81	0	e.	13			6 p.m.	29.73	77	0	se.	10		
10 a.m.	29.70	82	0	e.	16			7 p.m.	29.74	77	0	se.	9		
11 a.m.	29.68	82	0	e.	17			8 p.m.	29.73	77	0	se.	12	st.	se.
12 noon	29.67	80	0	e.	17	cu.	e.	9 p.m.	29.73	78	0	se.	16		
1 p.m.	29.64	80	0	e.	17			10 p.m.	29.72	79	0	se.	17		
2 p.m.	29.63	79	0	e.	17			11 p.m.	29.71	79	0	se.	17		
3 p.m.	29.62	78	T.	e.	15			12 mid.	29.69	79	0	se.	19		
4 p.m.	29.62	77	.01	e.	13			18th							
5 p.m.	29.62	77	.03	e.	10			1 a.m.	29.68	79	0	se.	17		
6 p.m.	29.61	76	.01	e.	11			2 a.m.	29.67	79	0	se.	16		
7 p.m.	29.61	76	.14	ne.	12			3 a.m.	29.66	79	0	se.	17		
8 p.m.	29.59	76	.10	ne.	14	nb.	n.	4 a.m.	29.65	79	.01	se.	21		
9 p.m.	29.56	76	.02	ne.	18			5 a.m.	29.64	76	.02	e.	20		
10 p.m.	29.53	76	.20	ne.	23			6 a.m.	29.63	76	.02	e.	23		
11 p.m.	29.50	76	.19	ne.	24			7 a.m.	29.59	75	.04	e.	26		
12 mid.	29.46	75	.37	ne.	27			8 a.m.	29.54	73	.22	e.	30	nb.	e.
18th								9 a.m.	29.45	72	.52	ne.	37		
1 a.m.	29.42	74	.33	ne.	26			10 a.m.	29.38	73	.32	ne.	51		
2 a.m.	29.36	75	.48	ne.	29			11 a.m.	29.28	74	1.02	ne.	55		
3 a.m.	29.30	74	.63	ne.	33			12 noon	29.26	72	.96	ne.	55	Center	
4 a.m.	29.32	73	.23	ne.	34	Center		1 p.m.	29.33	60	.73	ne.	44	Passed	
5 a.m.	29.36	75	.03	n.	41	Passed		2 p.m.	29.45	65	.62	n.	47	nb.	e.
6 a.m.	29.42	75	T.	nw.	38			3 p.m.	29.48	62	.12	nw.	41		
7 a.m.	29.48	72	T.	nw.	45			4 p.m.	29.53	67	.17	n.	32		
8 a.m.	29.57	74	.01	nw.	50	nb.	nw.	5 p.m.	29.60	65	.12	n.	25		
9 a.m.	29.60	72	T.	nw.	38			6 p.m.	29.60	64	.17	nw.	18		
10 a.m.	29.62	74	0	nw.	29			7 p.m.	29.61	64	.02	nw.	15		
11 a.m.	29.62	75	0	nw.	26			8 p.m.	29.61	64	T.	nw.	15	nb.	nw

TROPICAL CYCLONE IN THE FLORIDA STRAITS, OCTOBER 17 TO 19, 1906

BLE III 75th Meridian Time

	Key West, Florida. Latitude 24° 33′ N. Longitude 81° 48′ W. To the left of the line followed by the center of the cyclone, 50 miles.								Jupiter, Florida. Latitude 26° 57′ N. Longitude 80° 07′ W. To the left of the line followed by the center of the cyclone, 30 miles.							
	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS			Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction								Kind	Direction
h									18th							
oon	29.63	76	0	nw.	33				9 p.m.	29.61	64	0	nw.	14		
m.	29.64	78	0	nw.	30				10 p.m.	29.61	64	0	nw.	14		
m.	29.64	77	0	nw.	27				11 p.m.	29.61	65	0	w.	13		
m.	29.66	77	0	nw.	29				12 mid.	29.61	65	0	w.	16		
m.	29.67	77	0	nw.	27				19th							
m.	29.69	77	0	nw.	26				1 a.m.	29.61	66	0	w.	16		
m.	29.71	77	0	nw.	23				2 a.m.	29.62	66	0	w.	15		
m.	29.74	77	0	nw.	20				3 a.m.	29.64	67	0	w.	12		
m.	29.74	77	0	nw.	17	nb.	?		4 a.m.	29.66	68	0	w.	11		
m.	29.74	76	0	nw.	12				5 a.m.	29.68	69	0	w.	10		
m.	29.73	76	0	w.	12				6 a.m.	29.70	70	0	w.	11		
m.	29.74	75	0	w.	19				7 a.m.	29.72	71	0	w.	11		
d.	29.74	77	0	nw.	15				8 a.m.	29.73	72	0	w.	16	Cloudless	
h									9 a.m.	29.72	75	0	nw.	15		
m.	29.74	76	0	nw.	15				10 a.m.	29.69	77	0	nw.	13		
m.	29.74	76	0	nw.	19				11 a.m.	29.67	78	0	w.	16		
m.	29.74	76	0	w.	20				12 noon	29.65	80	0	w.	15		
m.	29.76	76	0	w.	20				1 p.m.	29.65	79	0	w.	18		
m.	29.78	75	0	w.	19				2 p.m.	29.66	78	0	w.	19		

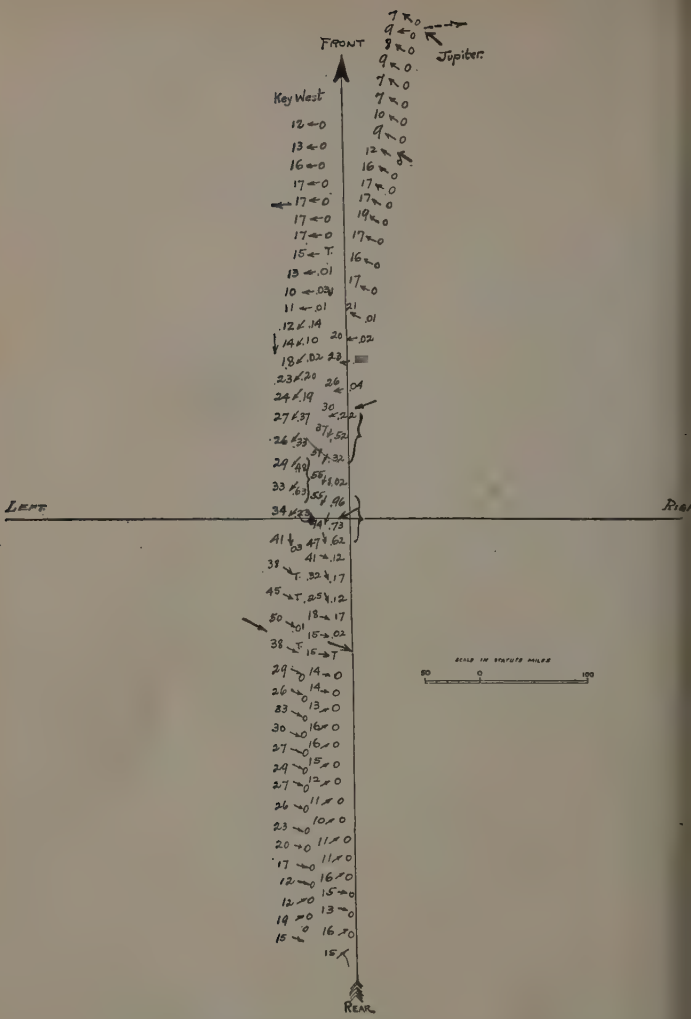


Figure 4. Records made during the passage of the tropical cyclone in the Florid Straits, October 17-19, 1906. Intersection of the cross lines represents the center o the cyclone. Points of small regular arrows rest on positions of stations at the tim the records were made. Figures on the left of the arrows are wind velocities in mile per hour; the figures on the right of the arrows are hourly precipitation measured t hundredths of an inch. Brackets show the greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of the smaller traveling cyclones.

IV

The Tropical Cyclone of September 19-21, 1909

etailed meteorological data recorded during the passage of tropical cyclone, September 19-21, 1909, are given in Table This cyclone advanced through the Yucatan Channel and Gulf of Mexico in a north-northwesterly direction, curving ly to the eastward as it approached the Louisiana Coast, re it moved inland east of Atchafalaya Bay, and thence hward across the Great Lakes as indicated by path "B" on re 2. The cyclonic conditions were mainly within the 29.6 ar. The distances inside the 29.6 isobar on the line dividing storm area into front and rear halves and on the line dividing to right and left halves are nearly equal, about 600 miles, the isobars were nearly circular. The speed with which this one advanced after reaching land was nearly twice the rate which it traveled while crossing the Gulf of Mexico.

he isobars as the cyclone moved inland on September 20th, e crowded together on the right and spread outward on left side. An area of high pressure over the New England the Atlantic States influenced conditions in this cyclone r it moved inland, but not until it had moved out of the tal plain.

he hourly winds and precipitation at Pensacola, Fla., Mobile, , and New Orleans, La., in the right half, and Galveston, as, in the left half of the cyclonic area are shown on Figure 5. wind directions in the right rear quadrant were in the same eral direction as that in which the cyclone was traveling. he right front quadrant the winds at Pensacola were inclined y from the center to some extent, while at New Orleans and ile they were inclined toward the center until about eight s before the passage of the center when they shifted and up a direction which was directly across the line along h the center was advancing. The wind directions in the half of the cyclone at Galveston, Texas, 200 miles to the of the line of advance, show a movement around through left front quadrant into the rear where their inclination

toward the center increased until they took a direction mainl
across the line along which the center traveled.

The lower clouds in the right front quadrant have direction
at all three stations, different from the surface winds; they hav
directions inclined to the right of the surface winds and chang
directions six to eight hours or more in advance of the surfac
winds. On the extreme right, at Pensacola, Fla., there is
pronounced inclination to the right in the direction of the lowe
clouds, so that they are almost parallel to the line of advance
the center of the cyclone.

There were five observations of cirrus clouds in the fron
half of the cyclone; two of these had the same general direc
tion as that in which the cyclone was traveling; three observa
tions at Galveston, Texas, 200 miles to the left of the line
advance, showed cirrus with directions successively from eas
southeast, and northeast within a period of five hours. Ther
were intermediate clouds from the northeast at the time th
cirrus were from the northeast. These shifting directions sho
confusion in the clouds at that level on the outer edge of tha
part of the cyclone. There were three observations of cirrus
the right rear quadrant, one almost directly in the rear and 22
miles from the center moving with the cyclone, and the othe
two, 250 and 325 miles, respectively, to the rear and almost
far to the right were moving away from the line of advanc
following the prevailing direction of the cirrus for this latitud

The distribution of hourly precipitation intensity in th
cyclone is very interesting. The greatest rainfall in any hou
was 1.00 inch at New Orleans, La., 75 miles to the right of th
line along which the center was advancing, and seven hours
time and 80 miles in space in front of the line dividing th
cyclone into front and rear halves. At Mobile, Ala., 200 mil
to the right of the line of advance, the greatest rainfall in fro
at any hour was .33 inch, when the line dividing the front an
rear halves of the cyclonic area was eight hours distant in tim
and 80 miles in space. At Pensacola, Fla., 250 miles to the rig
of the line along which the center advanced, the greatest hour
rainfall was .24 of an inch, three hours before the passage
the cyclonic center.

The precipitation diminished rapidly at all stations with th

rrence of the lowest barometer and soon ceased entirely. At Orleans *the precipitation in the front half of the storm was inches, and in the rear, .33 inch.* At Mobile the precipita- almost stopped with the passage of the storm center, but menced again and the period of greatest intensity occurred hours after the passage of and 125 miles in the rear of the m center. At Pensacola no precipitation worthy of men- occurred after the passage of the storm center. The pre- tation in the rear of the center at Mobile, Ala., doubtless cates a secondary disturbance in the cloud region attended he isolated rainfall in that part of the cyclonic area.

TROPICAL CYCLONE ON THE MIDDLE GULF COAST. SEPTEMBER 19 TO 21, 1909
TABLE IV 90th Meridian Time

Galveston, Texas.
Latitude 29° 18′ N. Longitude 94° 50′ W.
To the left of the line followed by the center of the cyclone, 205 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
19th							
1 p.m.	29.94	86	0	nw.	10		
2 p.m.	29.91	88	0	nw.	7		
3 p.m.	29.90	89	0	n.	5		
4 p.m.	29.89	88	0	ne.	7		
5 p.m.	29.89	88	0	ne.	7		
6 p.m.	29.89	86	0	ne.	4		
7 p.m.	29.88	85	0	ne.	4	ct. st.	s.
8 p.m.	29.88	84	0	ne.	1		
9 p.m.	29.89	84	0	ne.	3		
10 p.m.	29.89	84	0	ne.	7		
11 p.m.	29.87	83	0	ne.	13		
12 mid.	28.86	83	0	ne.	14		
20th							
1 a.m.	29.84	83	0	ne.	14		
2 a.m.	29.83	80	0	n.	15		
3 a.m.	29.82	79	0	n.	13		
4 a.m.	29.83	79	0	n.	17		
5 a.m.	29.84	80	0	n.	19		
6 a.m.	29.83	80	0	n.	22		
7 a.m.	29.81	80	0	n.	24	Ci. st.	e. n.
8 a.m.	29.80	79	0	n.	21		
9 a.m.	29.80	81	0	n.	21		
10 a.m.	29.76	82	0	n.	21	ci.	se.
11 a.m.	29.75	82	0	n.	23		
12 noon	29.71	82	0	n.	21	ci.	ne.
1 p.m.	29.70	82	0	nw.	22	a. cu.	ne.
2 p.m.	29.63	85	0	n.	25		
3 p.m.	29.62	83	0	n.	27		
4 p.m.	29.61	82	0	nw.	27		
5 p.m.	29.60	82	0	nw.	29	Center	
6 p.m.	29.59	82	0	nw.	28	Passed	
7 p.m.	29.60	82	0	nw.	27	a. st. cu.	nw. n.
8 p.m.	29.62	80	0	nw.	25		
9 p.m.	29.63	79	0	nw.	21		
10 p.m.	29.64	78	0	nw.	16		
11 p.m.	29.65	78	0	nw.	16		

New Orleans, La.
Latitude 29° 58′ N. Longitude 90° 04′ W
To the right of the line followed by th
center of the cyclone, 65 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUD	
						Kind	
19th							
3 p.m.	29.89	82	0	ne.	18		
4 p.m.	29.89	82	0	ne.	18		
5 p.m.	29.89	82	T.	ne.	20		
6 p.m.	29.88	79	.02	ne.	20		
7 p.m.	29.87	78	.01	ne.	16	st.	e
8 p.m.	29.87	78	.01	ne.	17		
9 p.m.	29.86	80	T.	ne.	18		
10 p.m.	29.85	81	T.	ne.	19		
11 p.m.	29.83	80	.02	ne.	20		
12 mid.	29.82	78	.03	ne.	17		
20th							
1 a.m.	29.78	76	.05	ne.	22		
2 a.m.	29.76	76	.15	ne.	23		
3 a.m.	29.75	74	.11	ne.	24		
4 a.m.	29.73	77	.03	ne.	26		
5 a.m.	29.71	75	.17	ne.	27		
6 a.m.	29.69	75	.16	ne.	28		
7 a.m.	29.68	75	.24	ne.	26	st.	e
8 a.m.	29.66	79	.20	ne.	26		
9 a.m.	29.64	78	.30	ne.	16		
10 a.m.	29.63	76	.18	ne.	29	st.	e
11 a.m.	29.58	76	.22	ne.	17		
12 noon	29.51	76	.31	e.	19	nb.	e
1 p.m.	29.42	74	1.00	e.	25		
2 p.m.	29.40	76	.26	e.	29	nb.	s
3 p.m.	29.33	79	.17	e.	33		
4 p.m.	29.31	77	.18	e.	39	nb.	s
5 p.m.	29.27	76	.11	e.	45		
6 p.m.	29.24	77	.18	se.	49		
7 p.m.	29.23	78	.07	se.	55	nb.	s
8 p.m.	29.26	76	.14	se.	47	Center	
9 p.m.	29.31	77	.11	se.	42	Passed	
10 p.m.	29.34	78	.01	se.	41		
11 p.m.	29.38	78	.03	se.	34		
12 mid.	29.42	76	.04	s.	29		

OPICAL CYCLONE ON THE MIDDLE GULF COAST. SEPTEMBER 19 TO 21, 1909
LE IV 90th Meridian Time

Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. The line left of the line followed by the center of the cyclone, 205 miles.								New Orleans, La. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 65 miles.							
	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction
								21st							
d.	29.65	76	0	nw.	13			1 a.m.	29.48	77	0	s.	25		
								2 a.m.	29.51	77	0	s.	19		
n.	29.66	75	0	w.	11			3 a.m.	29.58	77	0	s.	17		
n.	29.68	74	0	w.	9			4 a.m	29.62	77	0	s.	14		
n.	29.69	74	0	w.	13			5 a.m.	29.67	78	0	s.	13		
n.	29.69	73	0	w.	11			6 a.m.	29.69	78	0	s.	11	ci,	s.
n.	29.69	73	0	w.	6			7 a.m.	29.71	79	0	s.	11	a. st.	s.
n.	29.70	74	0	w.	5			8 a.m.	29.75	80	0	s.	9	cu.	s.
n.	29.71	75	0	w.	5	a. st.	w.	9 a.m.	29.79	76	T.	s.	9		
n.	29.74	77	0	w.	1	st.	s.	10 a.m.	29.79	75	T.	s.	10		
n.	29.76	79	0	nw.	5	st.	n.	11 a.m.	29.80	81	T.	s.	9		
n.	29.76	79	0	e.	4	st.	e.	12 noon	29.80	83	0	s.	10		
n.	29.75	82	0	ne.	8			1 p.m.	29.80	88	0	s.	10		
on	29.74	84	0	se.	10	st.	se.	2 p.m.	29.79	87	0	s.	9		
n.	29.72	85	0	s.	16			3 p.m.	29.78	87	0	s.	9		
n.	29.70	87	0	s.	19			4 p.m.	29.77	86	0	s.	7		
n.	29.67	88	0	s.	21	st.	se.	5 p.m.	29.78	86	0	s.	5		
n.	29.69	87	0	s.	17			6 p.m.	29.80	83	0	s.	4		
n.	29.69	86	0	s.	16			7 p.m.	29.80	81	0	s.	4	a. st.	s.
n.	29.70	84	0	s.	17										

TROPICAL CYCLONE ON THE MIDDLE GULF COAST. SEPTEMBER 19 TO 21, 1909

TABLE IV 90th Meridian Time

Mobile, Alabama.

Latitude 30° 41′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 195 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
19th							
2 p.m.	29.95	85	0	ne.	9		
3 p.m.	29.94	86	0	ne.	8		
4 p.m.	29.93	86	0	ne.	7		
5 p.m.	29.93	85	0	ne.	7		
6 p.m.	29.94	83	0	ne.	6		
7 p.m.	29.94	81	0	ne.	7	a. st. st.	0 se.
8 p.m.	29.94	81	0	ne.	8		
9 p.m.	29.95	81	0	ne.	8		
10 p.m.	29.94	81	0	ne.	8		
11 p.m.	29.93	81	0	ne.	9		
12 mid.	29.90	81	0	ne.	11		
20th							
1 a.m.	29.89	80	0	ne.	11		
2 a.m.	29.88	79	0	ne.	13		
3 a.m.	29.88	78	0	ne.	14		
4 a.m.	29.88	78	0	ne.	11		
5 a.m.	29.87	78	0	ne.	14		
6 a.m.	29.88	77	T.	ne.	15		
7 a.m.	29.88	77	T.	ne.	16	st.	e.
8 a.m.	29.87	77	T.	ne.	15		
9 a.m.	29.86	77	.02	ne.	16		
10 a.m.	29.85	75	.29	ne.	14		
11 a.m.	29.85	75	.24	ne.	15		
12 noon	29.82	76	T.	ne.	15	st.	e.
1 p.m.	29.78	76	.03	ne.	19		
2 p.m.	29.77	77	.01	ne.	18	st.	e.
3 p.m.	29.73	77	.01	e.	19		
4 p.m.	29.73	73	.33	e.	19		
5 p.m.	29.72	77	.12	e.	23		
6 p.m.	29.70	78	T.	e.	21		
7 p.m.	29.72	79	T.	e.	23	st.	e.
8 p.m.	29.71	79	.01	e.	27		
9 p.m.	29.68	81	T.	e.	26		
10 p.m.	29.68	81	T.	se.	30	st.	s.
11 p.m.	29.66	81	0	se.	35		
11:30 p.	Cent	er	Pa	sse	d		

Pensacola, Florida.

Latitude 30° 25′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 235 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
19th							
12 noon	29.97	83	0	e.	19		
1 p.m.	29.96	85	0	e.	21	a. st. st. cu.	e. e.
2 p.m.	29.94	85	0	e.	19		
3 p.m.	29.93	79	T.	e.	20		
4 p.m.	29.94	83	T.	e.	18		
5 p.m.	29.94	83	0	e.	18		
6 p.m.	29.94	82	0	e.	18		
7 p.m.	29.94	82	0	ne.	18	st. cu.	e.
8 p.m.	29.94	81	0	ne.	20		
9 p.m.	29.95	81	0	e.	24		
10 p.m.	29.95	81	0	e.	28		
11 p.m.	29.93	80	0	e.	23		
12 mid.	29.92	80	0	e.	36		
20th							
1 a.m.	29.89	80	0	e.	44		
2 a.m.	29.89	79	T.	e.	44		
3 a.m.	29.90	78	0	e.	43		
4 a.m.	29.90	77	T.	e.	37		
5 a.m.	29.91	77	T.	e.	40		
6 a.m.	29.90	76	T.	e.	41		
7 a.m.	29.89	78	.02	e.	36	st. cu.	se.
8 a.m.	29.90	79	T.	e.	47		
9 a.m.	29.89	78	T.	e.	51		
10 a.m.	29.89	77	.02	e.	53	st. cu.	se.
11 a.m.	29.88	76	.11	e.	49		
12 noon	29.87	73	.04	e.	44		
1 p.m.	29.84	75	.07	e.	42		
2 p.m.	29.82	78	.09	e.	44	st. cu.	se.
3 p.m.	29.79	76	.05	e.	46		
4 p.m.	29.78	80	.07	e.	50	st. cu.	se.
5 p.m.	29.78	79	.07	se.	51		
6 p.m.	29.77	76	.07	se.	50		
7 p.m.	29.77	80	.24	se.	49	nb.	se.
8 p.m.	29.78	76	.13	se.	52		
9 p.m.	29.80	79	T.	se.	43	Center	
10 p.m.	29.79	82	.01	se.	49	Passed	

OPICAL CYCLONE ON THE MIDDLE GULF COAST. SEPTEMBER 19 TO 21, 1909
E IV 90th Meridian Time

Mobile, Alabama.

de 30° 41′ N. Longitude 87° 13′ W. To the right of the line followed by the
e right of the line followed by the center of the cyclone, 195 miles.

Pensacola, Florida.

Latitude 30° 25′ N. Longitude 87° 13′ W.
To the right of the line followed by the
center of the cyclone, 235 miles.

	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
								20th							
.	29.64	81	.01	se.	34			11 p.m.	29.77	80	.01	se.	53		
								12 mid.	29.76	80	T.	se.	53		
.	29.64	82	.01	se.	33			21st							
.	29.62	81	.09	se.	38			1 a.m.	29.78	80	0	se.	47		
.	29.63	81	.01	se.	41			2 a.m.	29.80	81	T.	s.	51		
.	29.64	76	.32	se.	37			3 a.m.	29.80	81	0	s.	54		
.	29.67	79	.72	se.	33			4 a.m.	29.80	81	0	s.	51		
.	29.70	76	.05	se.	32			5 a.m.	29.80	81	0	s.	48		
.	29.74	80	.08	s.	25	st.	s.	6 a.m.	29.81	81	0	s.	47		
.	29.75	82	T.	s.	23			7 a.m.	29.80	81	0	s.	43	ci.	w.
.	29.76	84	0	s.	20			8 a.m.	29.82	82	0	s.	40	cu.	sw.
.	29.77	85	0	s.	21			9 a.m.	29.85	82	0	s.	39		
.	29.78	85	0	s.	24			10 a.m.	29.85	83	0	s.	36		
n	29.79	80	.09	s.	15			11 a.m.	29.86	83	0	sw.	32		
.	29.80	78	.02	sw.	16			12 noon	29.84	84	0	sw.	30	ci.	w.
.	29.79	81	0	sw.	13			1 p.m.	29.84	82	0	sw.	30	cu.	sw.
.	29.77	83	0	sw.	13			2 p.m.	29.83	82	0	sw.	29		
.	29.77	84	0	s.	14			3 p.m.	29.82	82	0	sw.	29		
.	29.79	83	0	s.	13			4 p.m.	29.82	82	0	sw.	26		
								5 p.m.	29.82	81	0	sw.	23		

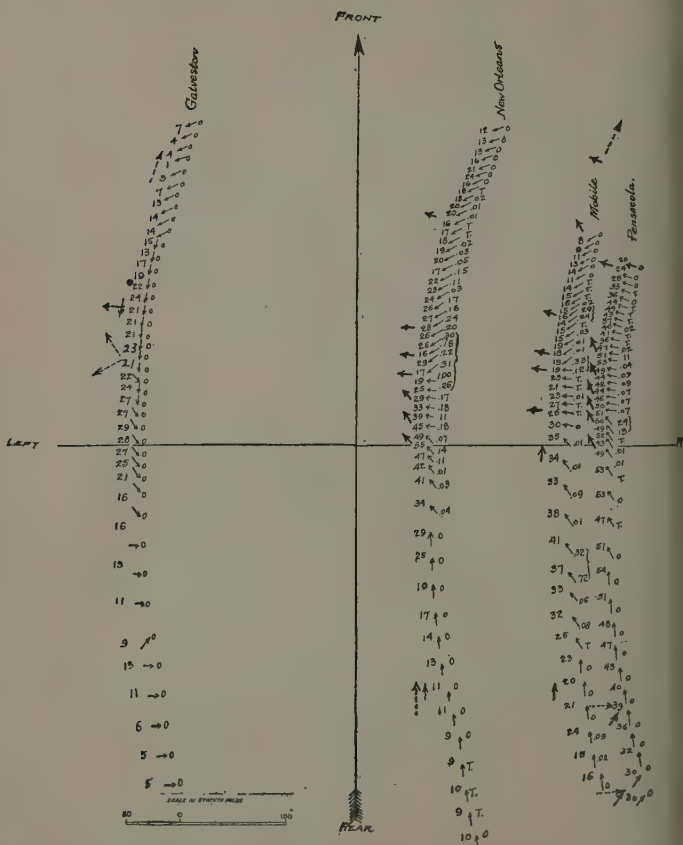


Figure 5. Records made during the passage of the tropical cyclone, Septem
19-21, 1909. Intersection of the cross lines represents the center of the cyclo
Points of small regular arrows rest on positions of stations at the time the reco
were made. Figures on the left of the arrows are wind velocities in miles per ho
the figures on the right of the arrows are the hourly precipitation measured
hundredths of an inch. Brackets show the greatest hourly precipitation intens
Heavy arrows represent the directions of the lower clouds.
Broken arrows represent the directions of upper clouds, the cirrus types.
This cyclone falls in the group of the larger traveling cyclones.

V

Tropical Cyclone of October 10-12, 1909

Meteorological data recorded during the passage of the tropi- cyclone of October 10-12, 1909, (26) through the Florida aits are shown in Table V. This disturbance moved northward he Caribbean Sea until it reached the western end of Cuba ere it curved and moved towards the northeast, its center sing almost directly over Key West, Fla., as shown in path Figure 2. Wind and precipitation records as related to the lonic center and its movement are given in Figure 6 for West, Jupiter, and Tampa, Fla. The changes in the wind ctions with the advance of the cyclone and changes of the ition of the stations in their relation to the cyclonic center very interesting. For two hours preceding the passage of cyclonic center the prevailing wind at Key West was almost ctly into the center, oscillating between N. and NE. and the passage of the center the wind shifted from NE. to ., 90 degrees, and blew directly across the line along which center was advancing, and it continued in that direction il this station passed out of the rear of the cyclone. The ds at Jupiter and Tampa moved around the center through left front quadrant into the left rear quadrant where they ted and soon showed increased inclination towards the center. West passed out through the rear almost directly on the along which the cyclonic center was advancing and the rease in the wind velocity at Key West a few hours after the sage of the center was greater than was the case at Jupiter, miles to the left of the line along which the center was ancing.

The directions of the lower clouds observed in the front of cyclone were either the same as the surface winds or were ined more away from the center, and in the rear were about same as the surface winds.

Precipitation commenced at Key West, Fla., 300 miles in nt of and 275 miles to the right of the line of advance of center at that hour, and 25 hours before the passage of the

storm center. The storm center curved directly over the Key West station. There were spurts of increased precipitation intensity from 20 to 14 hours before the passage of the storm center, when Key West was about 200 miles in front and 100 to 175 miles to the right of the line of advance at the time, and the cyclone curved towards the region over which the heaviest precipitation had previously occurred. Precipitation was excessively heavy with the shift of the wind directly into the storm center, two hours before its passage. *The total precipitation at this station before the passage of the cyclonic center was 12.04 inches; after the passage of the center, .24 inch.*

Jupiter, Florida, first appears in the cyclone area 400 miles in front of the center and 300 miles to the right of the line along which the center was advancing; later, after about 12 hours, this station passed into the left-hand half of the cyclone and as it moved back into the left rear quadrant was 95 miles to the left of the line followed by the center of the cyclone. The precipitation commenced at Jupiter 26 hours in advance of the passage of the center, when that station was well forward in the right front quadrant, and the heaviest rainfall during the passage of the cyclone occurred at that time. The precipitation at Jupiter diminished when the station passed into the left front quadrant and ceased before it passed into the left rear quadrant.

Latitude 27° 57′ N. Longitude 82° 27′ W. To the left of the line followed by the center of the cyclone, 230 miles.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
10th							
1 a.m.	30.04	70	0	ne.	7		
2 a.m.	30.01	69	0	ne.	6		
3 a.m.	30.00	69	0	ne.	6		
4 a.m.	30.00	68	0	ne.	7		
5 a.m.	29.99	68	0	ne.	6		
6 a.m.	29.98	69	0	ne.	7		
7 a.m.	30.00	71	0	ne.	7	a. st.	?
8 a.m.	30.01	76	0	ne.	9		
9 a.m.	30.01	80	0	ne.	12		
10 a.m.	30.00	80	0	e.	15		
11 a.m.	29.98	82	0	e.	13		
12 noon	29.95	84	0	e.	12	a. st.	?
					13	st. cu.	ne.
1 p.m.	29.93	84	0	e.	13		
2 p.m.	29.91	84	0	ne.	10		
3 p.m.	29.91	83	0	e.	11		
4 p.m.	29.91	82	0	e.	10		
5 p.m.	29.91	80	0	ne.	6		
6 p.m.	29.91	79	0	ne.	6		
7 p.m.	29.92	75	0	se.	7	st.	ne.

Latitude 26° 57′ N. Longitude 80° 07′ W. To the left of the line followed by the center of the cyclone, 95 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
10th							
1 a.m.	29.99	78	0	e.	19		
2 a.m.	29.97	78	0	e.	18		
3 a.m.	29.97	78	0	e.	18		
4 a.m.	29.97	78	0	e.	18		
5 a.m.	29.96	78	0	e.	19		
6 a.m.	29.96	78	0	e.	18		
7 a.m.	29.96	80	0	e.	17		
8 a.m.	29.98	80	0	e.	19	cu.	e.
9 a.m.	29.99	80	0	e.	17		
10 a.m.	29.98	80	0	e.	17		
11 a.m.	29.95	80	0	e.	14		
12 noon	29.93	80	0	e.	14		
1 p.m.	29.92	80	0	e.	15		
2 p.m.	29.88	80	0	e.	16		
3 p.m.	29.88	79	0	e.	15		
4 p.m.	29.88	75	.24	e.	17		
5 p.m.	29.88	72	.64	e.	14		
6 p.m.	29.88	73	.11	e.	11		
7 p.m.	29.88	74	.09	e.	10		

Latitude 24° 33′ N. Longitude 81° 48′ W. The center of the cyclone moved almost directly over the station, but a little to the right.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
10th							
1 a.m.	29.96	75	.05	e.	10		
2 a.m.	29.91	75	.15	e.	10		
3 a.m.	29.90	74	.01	e.	9		
4 a.m.	29.90	75	T.	e.	10		
5 a.m.	29.90	76	T.	e.	10		
6 a.m.	29.91	77	.03	e.	9		
7 a.m.	29.91	78	.01	e.	9		
8 a.m.	29.91	78	.02	e.	9	nb.	e.
9 a.m.	29.91	78	T.	e.	9		
10 a.m.	29.90	77	.41	se.	10		
11 a.m.	29.90	76	.11	se.	6	nb.	e.
12 noon	29.88	76	.05	se.	14		
1 p.m.	29.86	75	.03	e.	12		
2 p.m.	29.84	76	.22	e.	9	nb.	e.
3 p.m.	29.83	75	.06	e.	9		
4 p.m.	29.83	75	.30	ne.	11		
5 p.m.	29.83	75	.24	e.	11		
6 p.m.	29.82	74	.27	e.	10		
7 p.m.	29.81	75	.18	ne.	12		

TABLE V

Tampa, Florida.

Latitude 27° 57′ N. Longitude 82° 27′ W. To the left of the line followed by the center of the cyclone, 230 miles.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
10th							
8 p.m.	29.91	70	T.	se.	15		
9 p.m.	29.90	70	.07	e.	11		
10 p.m.	29.89	70	.05	ne.	6		
11 p.m.	29.87	70	.06	ne.	5		
12 mid.	29.84	70	.02	ne.	6		
11th							
1 a.m.	29.83	70	0	ne.	5		
2 a.m.	29.78	70	0	ne.	4		
3 a.m.	29.75	69	0	ne.	3		
4 a.m.	29.75	69	0	ne.	2		
5 a.m.	29.76	69	0	ne.	4		
6 a.m.	29.76	69	0	ne.	5		
7 a.m.	29.76	71	0	ne.	5	st.	ne.
8 a.m.	29.76	74	0	ne.	3		
9 a.m.	29.76	76	0	ne.	5	st.	e.
10 a.m.	29.75	78	0	ne.	4	st.	e.
11 a.m.	29.73	80	0	e.	4	st.	e.

Jupiter, Florida.

Latitude 26° 57′ N. Longitude 80° 07′ W. To the left of the line followed by the center of the cyclone, 95 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
10th							
8 p.m.	29.89	74	.09	e.	13	nb.	e.
9 p.m.	29.89	73	.04	e.	16		
10 p.m.	29.84	73	T.	e.	20		
11 p.m.	29.83	74	.02	e.	15		
12 mid.	29.78	74	.02	e.	13		
11th							
1 a.m.	29.77	74	T.	se.	13		
2 a.m.	29.76	74	.01	se.	12		
3 a.m.	29.76	75	.05	se.	13		
4 a.m.	29.76	76	.02	se.	12		
5 a.m.	29.76	76	.02	se.	10		
6 a.m.	29.76	75	.08	e.	11		
7 a.m.	29.76	75	.05	e.	13		
8 a.m.	29.76	74	.11	ne.	15	nb.	e.
9 a.m.	29.76	74	.17	ne.	12		
10 a.m.	29.74	74	.08	n.	8		
11 a.m.	29.73	73	.08	e.	10		

Key West, Florida.

Latitude 24° 33′ N. Longitude 81° 48′ W. The center of the cyclone moved almost directly over the station, but a little to the right.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
10th							
8 p.m.	29.81	74	.18	e.	11	nb.	e.
9 p.m.	29.81	74	.63	e.	6		
10 p.m.	29.78	74	.01	e.	12		
11 p.m.	29.76	73	.14	ne.	14		
12 mid.	29.74	73	.08	ne.	18		
11th							
1 a.m.	29.67	76	.08	e.	15		
2 a.m.	29.62	77	.30	e.	22		
3 a.m.	29.62	78	.07	se.	26		
4 a.m.	29.59	77	.25	e.	25		
5 a.m.	29.56	75	.01	e.	29		
6 a.m.	29.52	75	.36	se.	30		
7 a.m.	29.42	76	.31	se.	32		
8 a.m.	29.23	76	.29	e.	39	nb.	se.
9 a.m.	28.94	76	.66	e.	50		
10 a.m.	28.71	75	2.82	ne.	69	nb.	e.
11 a.m.	28.60	74	2.32	ne.	74	nb.	ne.

Latitude 27° 57′ N. Longitude 82° 27′ W. To the left of the line followed by the center of the cyclone, 230 miles.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
11th							
2 p.m.	29.66	79	T.	n.	4	Center	
3 p.m.	29.66	76	0	nw.	10	Passed	
4 p.m.	29.66	76	T.	nw.	10	st.	n.
5 p.m.	29.67	76	0	n.	7	st.	nw.
6 p.m.	29.68	76	0	nw.	6		
7 p.m.	29.70	76	0	nw.	8	st.	nw.
8 p.m.	29.72	74	0	nw.	6		
9 p.m.	29.74	74	0	nw.	5		
10 p.m.	29.75	73	0	nw.	7		
11 p.m.	29.74	73	0	nw.	7		
12 mid.	29.73	73	0	nw.	9		
12th							
1 a.m.	29.73	72	0	nw.	10		
2 a.m.	29.74	70	0	nw.	10		
3 a.m.	29.75	68	0	nw.	9		
4 a.m.	29.77	67	0	nw.	12		
5 a.m.	29.82	66	0	n.	10		
6 a.m.	29.85	64	0	nw.	9		
7 a.m.	29.87	66	0	nw.	10	st.	nw.

Latitude 26° 57′ N. Longitude 80° 07′ W. To the left of the line followed by the center of the cyclone, 95 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
11th							
2 p.m.	29.64	78	.04	e.	17	nb.	e.
3 p.m.	29.59	79	.02	e.	19		
4 p.m.	29.53	79	T.	e.	25	nb.	e.
5 p.m.	29.55	76	.02	e.	28	Center	
6 p.m.	29.56	76	T.	e.	32	Passed	
7 p.m.	29.57	77	.02	ne.	29	nb.	e.
8 p.m.	29.57	77	0	ne.	28	st.	e.
9 p.m.	29.58	78	0	ne.	28		
10 p.m.	29.59	79	0	ne.	20		
11 p.m.	29.59	77	0	n.	13		
12 mid.	29.60	73	0	nw.	14		
12th							
1 a.m.	29.61	73	0	nw.	15		
2 a.m.	29.63	73	0	n.	14		
3 a.m.	29.64	72	0	nw.	12		
4 a.m.	29.65	71	0	nw.	10		
5 a.m.	29.68	71	0	nw.	12		
6 a.m.	29.72	70	0	nw.	10		
7 a.m.	29.75	74	0	nw.	12		

Latitude 24° 33′ N. Longitude 81° 48′ W. The center of the cyclone moved almost directly over the station, but a little to the right.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
11th							
1 p.m.	29.14	71	.20	nw.	63	nb.	nw.
2 p.m.	29.27	74	.02	nw.	29		
3 p.m.	29.41	76	T.	nw.	21	nb.	nw.
4 p.m.	29.52	74	T.	nw.	13		
5 p.m.	29.56	76	0	nw.	13	nb.	nw.
6 p.m.	29.59	77	0	nw.	13		
7 p.m.	29.63	78	0	nw.	13		
8 p.m.	29.65	78	0	nw.	12		
9 p.m.	29.67	78	0	nw.	12		
10 p.m.	29.70	78	0	nw.	12		
11 p.m.	29.71	77	0	nw.	11		
12 mid.	29.72	77	0	nw.	11		
12th							
1 a.m.	29.72	77	0	nw.	11		
2 a.m.	29.72	76	0	nw.	10		
3 a.m.	29.72	76	0	nw.	10		
4 a.m.	29.74	75	0	nw.	10		
5 a.m.	29.76	75	0	nw.	10		
6 a.m.	29.79	74	0	nw.	9		

TABLE V — Tropical Cyclone Moving Through the Florida Straits, October 10 to 12, 1909

Tampa, Florida.
Latitude 27° 57′ N. Longitude 82° 27′ W. To the left of the line followed by the center of the cyclone, 230 miles.
90th Meridian Time

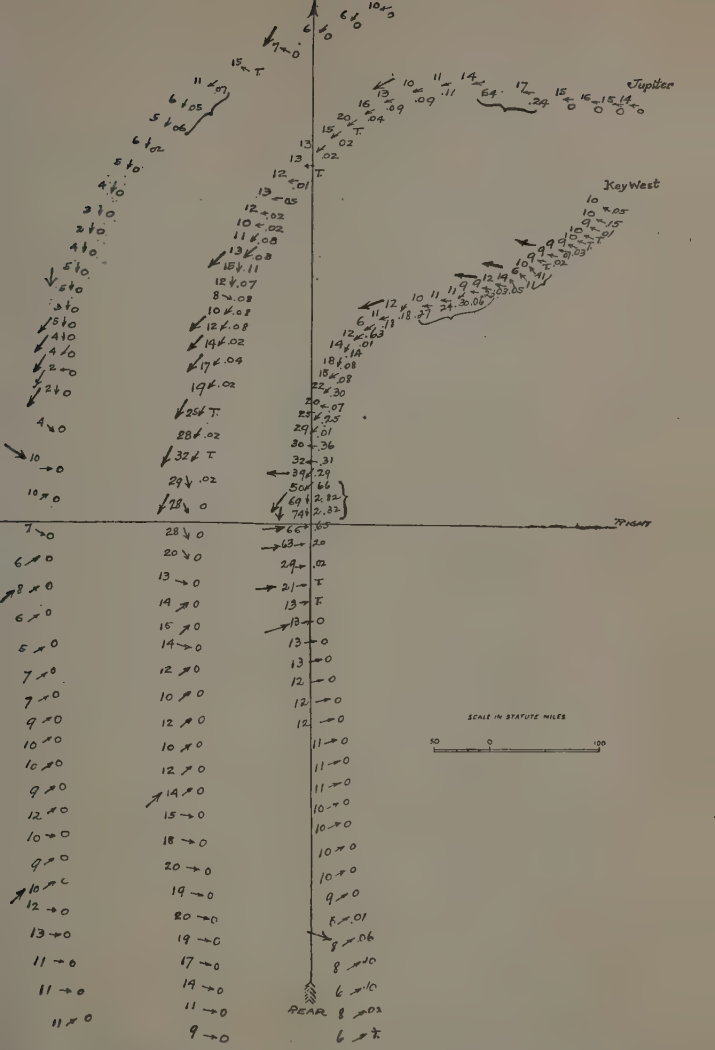
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
12th							
8 a.m.	29.88	72	0	n.	12		
9 a.m.	29.91	74	0	n.	13		
10 a.m.	29.92	76	0	n.	11		
11 a.m.	29.90	76	0	n.	11		
12 noon	29.89	77	0	nw.	11		
1 p.m.	29.89	78	0	nw.	12		
2 p.m.	29.89	76	0	nw.	12		
3 p.m.	29.89	76	0	nw.	10		
4 p.m.	29.91	75	0	nw.	11		
5 p.m.	29.93	72	0	nw.	7		
6 p.m.	29.96	70	0	nw.	7		
7 p.m.	29.98	70	0	nw.	6	Cloudless	
8 p.m.	29.99	69	0	nw.	7		
9 p.m.	30.01	67	0	nw.	8		
10 p.m.	30.02	66	0	nw.	9		

Jupiter, Florida.
Latitude 26° 57′ N. Longitude 80° 07′ W. To the left of the line followed by the center of the cyclone, 95 miles.
75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
12th							
8 a.m.	29.77	76	0	nw.	14	a. st.	nw.
9 a.m.	29.79	78	0	n.	15		
10 a.m.	29.80	80	0	n.	18		
11 a.m.	29.81	80	0	n.	20		
12 noon	29.80	80	0	n.	19		
1 p.m.	29.80	80	0	n.	20		
2 p.m.	29.81	79	0	n.	19		
3 p.m.	29.85	78	0	n.	17		
4 p.m.	29.87	76	0	n.	14		
5 p.m.	29.89	74	0	n.	11		
6 p.m.	29.91	71	0	n.	9		
7 p.m.	29.92	71	0	n.	9	Cloudless	
8 p.m.	29.93	71	0	n.	8		
9 p.m.	29.96	69	0	n.	7		
10 p.m.	29.97	68	0	nw.	7		

Key West, Florida.
Latitude 24° 33′ N. Longitude 81° 48′ W. The center of the cyclone moved almost directly over the station, but a little to the right.
75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
12th							
7 a.m.	29.84	73	.01	nw.	5		
8 a.m.	29.84	74	.06	nw.	8	nb.	n.
9 a.m.	29.86	78	.10	nw.	8		
10 a.m.	29.86	80	.10	nw.	6		
11 a.m.	29.86	81	.02	nw.	8		
12 noon	29.85	81	T.	nw.	6		
1 p.m.	29.85	81	0	n.	7		
2 p.m.	29.86	80	0	n.	8		
3 p.m.	29.86	78	0	n.	7		
4 p.m.	29.87	77	0	n.	6		
5 p.m.	29.88	76	0	n.	6		
6 p.m.	29.89	76	0	n.	7		
7 p.m.	29.92	76	0	n.	7		
8 p.m.	29.92	75	0	n.	5	ci.st.	n.
9 p.m.	29.93	75	0	ne.	6		



ue 6. Records made during the passage of the tropical cyclone through the Florida
s, October 10-12, 1909. Intersection of cross lines represents the center of the cyclone.
of small regular arrows rest on positions of stations at the time the records were made.
es on the left of the arrows are wind velocities in miles per hour; figures on the right
e arrows are the hourly precipitation measured to hundredths of an inch. Brackets show
reatest hourly precipitation intensity.
vy arrows represent the directions of the lower clouds.
ken arrows represent the direction of the upper clouds, the cirrus types.
e cyclone falls in the group of the smaller traveling cyclones.

VI

Tropical Cyclone of August 26-29, 1911

The cyclone of August 26-29, 1911, (27) was first noted i Lat. 28°, Long. 73°. This disturbance followed a west-northwe course until it reached the Atlantic Coast about 20 miles nort of Savannah, Ga., when it drifted first slowly towards th south, then westward and northward over western Georgi gradually diminishing in intensity and finally dying out. Th storm, unlike most tropical cyclones, did not continue to advanc on reaching land. The path along which the center of th cyclone advanced is shown by path "K," Figure 2. Detaile meteorological data recorded during this cyclone are given i Table VI. The distribution of winds and precipitation as relate to the cyclonic center are shown in Figure 7. The winds move somewhat around the cyclonic center with varying inclinatio towards the center except in the left front quadrant, where the have inclinations somewhat away from the center.

The wind records in the front of the cyclonic area were mad while the cyclone was advancing and those in the rear ha while it was not advancing, but merely drifting with no definit direction.

The directions of the lower clouds were the same as the surfac winds except in the left front quadrant the directions we inclined away from the center more than the surface wind Cirrus clouds at Wilmington, N. C., 225 miles in front of th cyclonic center, had directions opposed to the direction in whic the cyclone was traveling. At Savannah, Ga., and Charleston S. C., cirrus clouds 200 to 250 miles in advance of the cent were across the line along which the cyclonic center was trave ing. At Savannah, two successive observations of cirrus cloud 90 to 70 miles, respectively, in front of the center, showed d rections opposed to the direction in which the cyclone wa traveling. The area of greatest intensity of precipitation shifte backward and to the left of the line along which the cent was advancing during the 24 hours following the observatio

he opposing cirrus clouds. The area of lowest pressure fol-
ed the line of greatest precipitation intensity.
'he distribution of precipitation and the occurrence of hourly
cipitation intensity about the cyclonic center differ greatly
n that found in cyclones which continued to advance. The
atest intensity of precipitation occurred at Charleston, S. C.,
hours in time and 110 miles in space in advance of the
lonic center, and there was another increase in precipitation
ensity two to six hours before the center passed Charleston.
e cyclonic center continued to advance towards and reached
; area of greatest precipitation intensity about midnight of
gust 27-28.
Vhen the center of the cyclone was near Savannah, Ga., on
morning of August 28th, the greatest hourly precipitation
ensity had shifted well to the left of the line along which the
ter had been advancing. Exceptionally heavy rains fell in
theastern Georgia and in northeastern Florida, as shown in
ble VI-a.
About 24 hours after the storm center had passed Charleston,
C., that station, then 150 miles in the rear of the cyclonic
ter, passed from the right rear quadrant into the left rear
drant, as the result of the changing position of the cyclonic
ter; moderately intense precipitation occurred at Charleston
that time. The heavy rainfall at Charleston was about 10
rs after the greatest hourly precipitation intensity at Sa-
nah, Ga., which also occurred immediately after Savannah
l passed into the left rear quadrant of the cyclone. This
cipitation in the left rear quadrant occurred at Charleston
l Savannah about the time that excessively heavy precipita-
n was occurring over southeastern Georgia and northeastern
rida, in the left front quadrant of the cyclone. When the
a of greatest hourly precipitation intensity shifted to the
of the line along which the cyclonic center had been ad-
ncing, the area of lowest pressure ceased to advance and
fted towards and followed the area of heaviest precipitation.
The storm area hovered over Georgia during August 28th,
h, and 30th, with the lowest barometer regularly following
area of greatest precipitation. When the heavy precipi-
ion, instead of continuing to occur in front of the cyclone,

shifted from the right into the left portion of the cyclonic ar
and backward into the rear of the cyclone, the intensity of t
disturbance diminished rapidly and the cyclone gradually fil
up. The air current in which the cyclone had been traveli
was evidently overcome by a counter current. The existence
such a counter current was indicated by the cirrus cloud mo
ments in the front of the cyclone with directions opposed to th
from which the cyclone approached.

Latitude 32° N. Longitude 81° W. Barometer 29.92. Thermometer 74°. Wind N.W. Rain 0.
To the left of the line followed by the center of the cyclone, 20 miles.

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
27th	29.92	75	0	n.	14		
3 a.m.	29.92	74	0	nw.	15		
4 a.m.	29.91	74	0	nw.	20		
5 a.m.	29.92	74	0	nw.	19		
6 a.m.	29.92	74	0	nw.	19	ci. st.	ne.
7 a.m.	29.92	76	0	nw.	20	st. cu.	ne.
8 a.m.	29.92	79	0	nw.	23		
9 a.m.	29.89	81	0	nw.	26		
10 a.m.	29.87	84	0	nw.	29	ci. st.	n.
11 a.m.	29.84	86	0	nw.	30	a. st.	n.
12 noon	29.83	84	0	nw.	31	st. cu.	n.
1 p.m.	29.83	86	0	nw.	29	st.	n.
2 p.m.	29.82	75	.08	n.	25	ci. st.	nw.
3 p.m.	29.76	79	0	nw.	24	st. cu.	nw.
4 p.m.	29.74	82	0	nw.	32		
5 p.m.	29.73	75	T.	nw.	34		
6 p.m.	29.72	79	.14	nw.	27	a. st.	n.
7 p.m.	29.71	79	0	nw.	39	st.	n.
8 p.m.	29.68	78	0	nw.	35		
9 p.m.	29.65	80	0	nw.	43		
10 p.m.	29.59	79	0	nw.	52		
11 p.m.							

Latitude 32° N. Longitude 81° W. Barometer 29.97. Thermometer 82°. Wind N.W. Rain 0.
To the right of the line followed by the center of the cyclone, 50 miles.

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
26th	29.97	82	0	ne.	13	ci. st.	0
8 p.m.	29.98	81	0	ne.	15	a. st.	se.
9 p.m.	29.98	81	0	n.	14		
10 p.m.	29.98	81	0	n.	17		
11 p.m.	29.97	81	0	n.	19		
12 mid.	29.96	75	0	n.	19		
27th							
1 a.m.	29.94	77	.04	ne.	16		
2 a.m.	29.89	76	0	n.	15		
3 a.m.	29.86	77	0	n.	19		
4 a.m.	28.85	78	0	n.	23		
5 a.m.	29.84	78	0	n.	23		
6 a.m.	29.83	72	.08	n.	25		
7 a.m.	29.83	75	.26	n.	23		
8 a.m.	29.83	76	.07	n.	25	st.	n.
9 a.m.	29.81	76	.82	n.	22		
10 a.m.	29.78	78	T.	n.	30		
11 a.m.	29.76	80	T.	n.	34		
12 noon	29.75	76	.31	n.	34		
1 p.m.	29.73	78	.01	n.	38		
2 p.m.	29.67	78	.01	n.	42		
3 p.m.	29.66	77	.08	n.	37		

To the right of the line followed by the center of the cyclone, 190 miles.

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS KIND	CLOUDS DIRECTION
26th	30.09	76	0	ne.	6	ci.	w
8 a.m.	30.10	80	0	ne.	8	ci. st.	n.
9 a.m.	30.11	84	0	ne.	9		
10 a.m.	30.10	85	0	ne.	12		
11 a.m.	30.08	86	0	ne.	12		
12 noon	30.07	86	0	e.	13		
1 p.m.	30.04	86	0	e.	13		
2 p.m.	30.02	85	0	e.	13		
3 p.m.	30.00	84	0	e.	15		
4 p.m.	30.02	83	0	e.	15		
5 p.m.	30.00	81	0	ne.	12		
6 p.m.	30.00	80	0	ne.	11		
7 p.m.	30.00	80	0	ne.	10	st.	ne.
8 p.m.	30.00	80	0	ne.	10		
9 p.m.	30.02	80	0	ne.	9		
10 p.m.	30.03	79	0	ne.	11		
11 p.m.	30.01	79	0	ne.	10		
12 mid.	30.00	79	0	ne.			
27th							
1 a.m.	29.99	79	0	ne.	10		
2 a.m.	29.98	79	0	ne.	13		
3 a.m.	29.95	79	0	ne.	14		

TABLE VI — TROPICAL CYCLONE ON THE SOUTH ATLANTIC COAST, AUGUST 26 TO 29, 1911
75th Meridian Time

Savannah, Georgia.
Latitude 32° 05′ N. Longitude 81° 05′ W.
To the left of the line followed by the center of the cyclone, 20 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
27th							
12 mid.	29.55	80	0	nw.	56		
28th							
1 a.m.	29.46	77	0	nw.	59		
2 a.m.	29.37	75	0	nw.	65		
3 a.m.	29.27	74	.01	nw.	69		
4 a.m.	29.20	71	.04	nw.	81		
5 a.m.	29.12	71	.05	nw.	82		
6 a.m.	29.07	72	.04	nw.	80		
7 a.m.	29.05	72	.08	nw.	74		
8 a.m.	29.02	73	.03	nw.	66	nb.	nw.
9 a.m.	29.05	75	.08	nw.	37	Center	
10 a.m.	29.17	73	.06	sw.	22	Passed	
11 a.m.	29.27	72	.29	s.	43		
12 noon	29.37	72	.33	s.	58		
1 p.m.	29.44	72	.21	s.	55		
2 p.m.	29.51	73	.12	s.	49		
3 p.m.	29.54	73	.13	s.	43		
4 p.m.	29.57	73	.39	s.	38		

Charleston, South Carolina.
Latitude 32° 47′ N. Longitude 79° 56′ W.
To the right of the line followed by the center of the cyclone, 50 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
27th							
4 p.m.	29.63	78	.01	ne.	32		
5 p.m.	29.61	76	.02	ne.	39		
6 p.m.	29.59	74	.09	ne.	42		
7 p.m.	29.56	73	.27	ne.	49		
8 p.m.	29.53	74	.10	ne.	52	nb.	ne.
9 p.m.	29.48	75	.23	ne.	59		
10 p.m.	29.47	75	.17	ne.	70		
11 p.m.	29.46	76	.06	ne.	66		
12 mid.	29.38	75	.04	se.	88	Center	
28th						Passed	
1 a.m.	29.40	74	.06	se.	63		
2 a.m.	29.43	75	.08	se.	50		
3 a.m.	29.46	74	.04	se.	42		
4 a.m.	29.49	75	.03	se.	39		
5 a.m.	29.51	74	.01	se.	37		
6 a.m.	29.59	75	.04	se.	35		
7 a.m.	29.63	80	T.	se.	45		
8 a.m.	29.68	74	.10	se.	48	nb.	se.

Wilmington, North Carolina.
Latitude 34° 14′ N. Longitude 77° 57′ W.
To the right of the line followed by the center of the cyclone, 190 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
27th							
4 a.m.	29.94	79	0	ne.	14		
5 a.m.	29.94	80	0	ne.	16		
6 a.m.	29.96	80	0	ne.	15		
7 a.m.	29.99	80	0	ne.	18		
8 a.m.	29.99	71	.14	e.	19	nb.	e.
9 a.m.	29.99	71	.54	e.	16		
10 a.m.	29.98	75	.26	e.	16		
11 a.m.	29.96	78	T.	e.	16	st.	e.
12 noon	29.93	81	T.	e.	23	nb.	e.
1 p.m.	29.92	81	.02	e.	24		
2 p.m.	29.90	81	.11	e.	17	st.	e.
3 p.m.	29.89	82	0	e.	22	Center Passed	
4 p.m.	29.90	81	0	e.	22	st.	e.
5 p.m.	29.91	81	0	e.	20		
6 p.m.	29.91	81	0	e.	20		
7 p.m.	29.92	80	0	e.	17		
8 p.m.	29.92	80	0	e.	18	st.	e.

Latitude 32° 05′ N. Longitude 81° 05′ W. To the left of the line followed by the center of the cyclone, 20 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
28th							
8 p.m.	29.65	74	.19	s.	48	nb.	s.
9 p.m.	29.68	74	.08	s.	45		
10 p.m.	29.70	73	.06	s.	38		
11 p.m.	29.72	71	.14	s.	41		
12 mid.	29.73	74	.03	s.	38		
29th							
1 a.m.	29.74	74	T.	s.	33		
2 a.m.	29.74	73	T.	s.	35		
3 a.m.	29.78	73	0	s.	29		
4 a.m.	29.79	74	0	s.	25		
5 a.m.	29.81	75	0	s.	24		
6 a.m.	29.82	75	T.	s.	27		
7 a.m.	29.86	76	T.	s.	20		
8 a.m.	29.87	76	T.	s.	24	st.	s.
9 a.m.	29.90	73	T.	s.	19		
10 a.m.	29.89	76	T.	s.	16		
11 a.m.	29.88	78	T.	s.	22		
12 noon	29.88	76	0	s.	25		
1 p.m.	29.88	78	0	s.	27		
2 p.m.	29.87	79	0	s.	27		

Latitude 32° 47′ N. Longitude 79° 56′ W. To the right of the line followed by the center of the cyclone, 50 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
28th							
12 noon	29.79	79	.04	se.	44		
1 p.m.	29.79	81	0	se.	37		
2 p.m.	29.79	82	T.	se.	37		
3 p.m.	29.78	81	0	se.	35		
4 p.m.	29.79	80	0	se.	33		
5 p.m.	29.78	80	0	se.	33		
6 p.m.	29.77	80	0	se.	37		
7 p.m.	29.78	80	0	se.	35		
8 p.m.	29.81	71	.07	se.	30	nb.	s.
9 p.m.	29.83	80	T.	se.	28		
10 p.m.	29.85	80	0	se.	28		
11 p.m.	29.86	73	.26	se.	29		
12 mid.	29.86	73	.24	se.	28		
29th							
1 a.m.	29.88	69	.05	se.	32		
2 a.m.	29.87	74	.05	se.	38		
3 a.m.	29.86	77	.03	se.	28		
4 a.m.	29.88	71	.70	s.	23		
5 a.m.	29.90	74	.10	se.	16		
6 a.m.	29.90	76	T.	se.	23		
7 a.m.	29.91	73	.31	s.	22		

Latitude 34° 14′ N. Longitude 77° 37′ W. To the right of the line followed by the center of the cyclone, 190 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
27th							
12 mid.	29.95	80	0	e.	18		
28th							
1 a.m.	29.95	80	0	e.	16		
2 a.m.	29.94	80	0	e.	15		
3 a.m.	29.94	79	0	e.	16		
4 a.m.	29.96	79	0	e.	15		
5 a.m.	29.97	79	0	e.	13		
6 a.m.	29.99	79	0	e.	12		
7 a.m.	29.99	79	0	e.	12	ci. st.	e.
8 a.m.	29.99	81	0	e.	15	cu.	se.
9 a.m.	30.00	82	0	se.	17		
10 a.m.	30.00	82	0	se.	21		
11 a.m.	30.00	82	0	se.	20		
12 noon	30.00	82	0	se.	20	cu.	se.
1 p.m.	29.99	84	0	se.	21		
2 p.m.	29.98	83	0	se.	18	cu.	se.
3 p.m.	29.97	82	0	se.	20		
4 p.m.	29.96	82	0	se.	18		
5 p.m.	29.95	81	0	se.	18		
6 p.m.	29.96	81	0	se.	17		

TABLE VI-a

HEAVY RAINFALL IN THE COAST REGION OF SOUTH CAROLINA, GEORGIA AND NOR
FLORIDA IN A DYING CYCLONE, AUGUST 27 TO 30, 1911
75th Meridian Time

STATION	August 27th		August 28th		August 29th		August 30th		August 31st	
	a. m.	p.m.	a.m.	p.m.	a. m.	p. m.	a.m.	p.m.	a.m.	p.
Georgetown, S. C.		2.00		3.00		T.		T.		
Charleston, S. C.*		2.67		.97		1.26		0		
Smiths Mills, S. C.			1.51		1.79		1.25		.73	
Kingstree, S. C.		0	2.44		2.38		.20		.55	
Savannah, Ga.*		.22		2.95		T.		.01		
Statesboro, Ga.	.53		1.54		.56		.62		.32	
Glenville, Ga.	0		2.52		2.05		.11		T.	
Hilliard, Fla.		0		1.75		10.75		.35		
Fernandina, Fla.	0		.06		7.60		.12		.03	
St. George, Fla.	0		0		18.00		1.12		T.	
Macclenny, Fla.		0		.40		8.60		.52		
Johnstown, Fla.		0		.50		3.75		.75		
Lake City, Fla.	0		0		5.00		3.00		T.	
Fenholloway, Fla.		0		.15		1.40		4.10		
Jasper, Fla.		.23		.78		6.10		1.05		
Valdosta, Ga.	0		.45		1.50		5.40		T.	
Quitman, Ga.	0		0		.87		3.70		.93	
Lumber City, Ga.	.02		0		4.15		9.37		.62	
Helena, Ga.		.01		.39		4.05		4.06		
Abbeville, Ga.	0		T.		1.45		3.06		0	
Dublin, Ga.	0		0		1.30		1.87		1.02	
Millen, Ga.	0		0		.70		1.00		2.40	

*Midnight to midnight; other entries at 8 a.m. or (p.m.) about sunset.

OPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

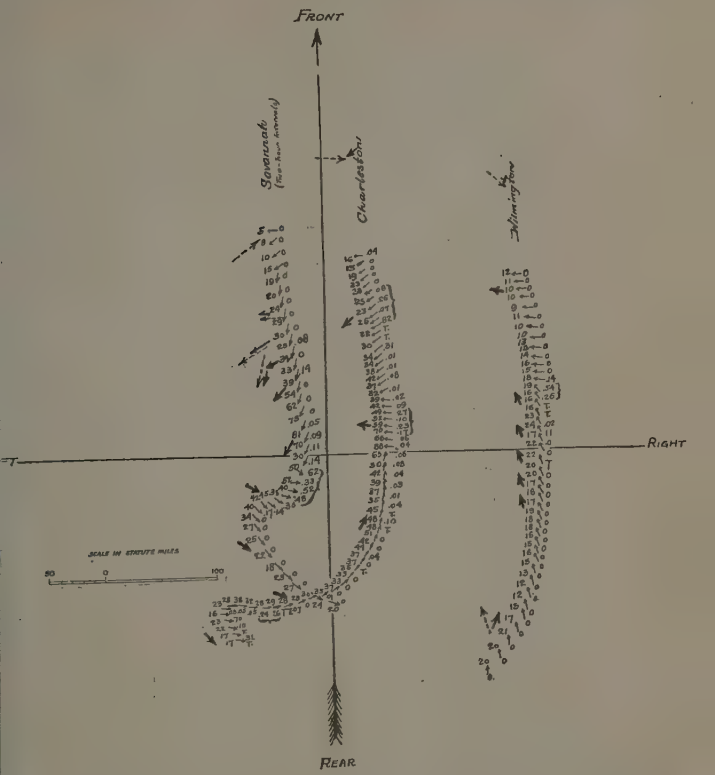


Figure 7. Records made during the passage of the tropical cyclone, August -28, 1911. Intersection of cross lines represents the center of the cyclone. Points small regular arrows rest on positions of stations at the time the records were ade; figures on the left of the arrows are wind velocities in miles per hour; the ures on the right of the arrows are the hourly precipitation measured to hundredths an inch. Brackets show greatest hourly precipitation intensity.
Heavy arrows represent the directions of the lower clouds.
Broken arrows represent the directions of the upper clouds, the cirrus types.
This cyclone falls in the group of the smaller cyclones which ceased to advance moving inland,

VII

Tropical Cyclone on Texas Coast August 15-18, 1915

Detailed meteorological data in the tropical cyclone of Augu 15-18, 1915, (17) during the time it was moving inland a given in Table VII. Barometer readings at Velasco, Texa during the passage of the cyclone are shown in Table VII-a.

This cyclone advanced through the Yucatan Channel ar thence in a northwesterly direction across the Gulf of Mexic The center of the storm moved inland on the Texas Coast a litt west of Galveston and Houston, Texas, and continued to mo northwestward until the center was 150 miles inland, when commenced to recurve towards the northeast. The cyclone aft curving continued to advance northeastward and moved out ov Lake Erie and the St. Lawrence Valley, as shown on path "C Figure 2. The rate of travel during the period of curvatu was less than half the rate before the cyclone commenced curvi and after the curving ceased.

The hourly winds and precipitation during the passage of t cyclone of August 16-22, 1915, as related to the cyclonic cent and its direction of movement are shown on Figure 8, for Ne Orleans, La., Galveston, (hourly precipitation missing), ar Houston, Texas, in the right half, and Corpus Christi, Texa in the left half of the cyclonic area. The wind directions in t right rear quadrant were continuously in the same general dire tion as that in which the cyclonic center was advancing, no withstanding the fact that the stations were carried backwa away from the center well across the right rear quadrant whi the cyclone was curving. In the right front quadrant, at Hou ton and Galveston, Texas, 15 and 50 miles respectively to t right of the line followed by the center, the wind directions first showed considerable inclination towards the cyclonic cente but when these stations were 125 miles in front of the center t winds shifted, their inclination towards the center diminishe and the directions were almost directly across the line of advan and continued so until the stations were near the center, wh the directions shifted more into the line of advance of t

lone. At Corpus Christi, in the left front quadrant, the winds ved around the center into the left rear quadrant where they e inclined more towards the center.

Lower clouds in the front of the cyclone at Galveston had a ection directly across the line of advance eight hours before winds shifted to the same direction. In the right rear drant the lower clouds had the same general direction as surface winds. One observation of cirrus with a doubtful ection is recorded at Corpus Christi, 275 miles in front and miles to the left of the line along which the center of the lone was traveling at that time. In the rear of the cyclone re are 10 observations at which cirrus clouds were recorded. ht of these in the right rear quadrant have directions mainly same as that in which the cyclone was traveling. One in left rear quadrant and one in the right rear quadrant have ections across the line of advance.

This is the only large tropical cyclone which has traveled oss the United States without encountering important moun- n ranges in its path or an area of high pressure of sufficient ent to influence the course of the cyclone and the winds and cipitation within the cyclonic area. After the recurve its ter continued to advance northeastward over the central ssissippi Valley and thence over Lake Erie, leaving the Appa- nian Plateau several hundred miles to the right of the path he center of the cyclone. In this cyclone, we have an oppor- ity to study the effects of elevated regions lying outside the lonic area proper, on the precipitation of the aqueous vapor n air drawn over the mountains by the cyclonic circulation, well as the influence of these mountains on the precipitation the cyclone.

Light precipitation commenced in the right front quadrant Houston, Texas, when the storm center was 230 miles distant space and 18 hours in time. An increase in hourly precipi- ion intensity appeared 14 hours before the passage of the rm center and when it was 180 miles distant; the intensity reased steadily for several hours, reaching 1.11 inches in an ur when the storm center was distant 85 miles in space and 7 urs in time. During eight hours commencing when the storm ter was 180 miles distant in space and 14 hours in time and

continuing until the center was 70 miles distant in space and si hours in time, the precipitation at Houston, Texas, was 4.4 inches. In these eight hours, ending six hours before the passag of the cyclonic center, 59% of the total precipitation during th 39 hours' duration of the cyclone was recorded; there was secondary period of heavy rainfall, commencing about two an a half hours before the passage of the storm center, the tot for the two hours being 1.47 inches. *The precipitation at Hou ton, Texas, during the passage of the front half of the cyclon was 7.13 inches, while the total amount in the rear half of th cyclone was only .39 inch.*

At New Orleans, La., 300 miles to the right of the line alon which the storm center advanced, precipitation commenced whe the line dividing the storm area into front and rear halves wa 250 miles distant. The period of greatest hourly precipitatio intensity was about 100 miles in space and 10 hours in tim before the occurrence of the lowest barometer, and no precip tation occurred after the storm center passed that station. A Corpus Christi, Texas, about 180 miles to the left of the lin along which the center advanced, no precipitation worthy o mention was recorded.

This cyclone furnished an exceptionally interesting examp for the study of changes in pressure distribution and the shap of the isobars in a tropical cyclone as it moved in on the coa and thence northward and northeastward for some 2000 mil (covering a period of seven days' movement), with pressu records exceptionally well distributed in the cyclonic area so th the spacing of the isobars requires little interpolation. Th forms of the isobars and the gradients at different stages i the progress of this cyclone, from the time it reached the Gu Coast until it moved across Lake Erie, are shown on a series o maps described in the following discussion.

There are sufficient pressure records at 5 a. m., August 1 1915, Figure 9, from which accurate isobars and gradients a shown from 28.3 to 29.7 inches, a range of 1.4 inches. Th cyclone proper falls within the 29.7 isobar. The diameter o the 29.7 isobar on a line at right angles to the line of advan is about 475 miles. The isobars are in the main circular in for up to 29.4 inches. Beyond the 29.4 isobar, the isobars we

wded on the right side and spread out forming a bulge on the side of the cyclonic area.

The diameter of the 29.4 isobar as shown on Figure 9, was miles. The distance between the 28.3 isobar and the 29.4 bar was 105 miles, showing an average gradient of about .01 h per mile. Between the 28.3 and the 28.9 isobar the gradient raged .02 of an inch to the mile. The diameter of the 28.9 bar was 95 miles.

Pressure distribution in the cyclonic area at 11 a. m., August h, six hours later than the preceding map, is shown in Figure The cyclonic center at this time had been inland between 8 d 10 hours, and was about 125 miles distant from the coast. y little change had taken place in the forms of the isobars he cyclonic area, the isobars within 29.5 inches being nearly ular, but outside of this the isobars were crowded together he front of the cyclone with a spreading out in the left rear drant, showing a bulge in that quarter, a change from the vious map, in the position of crowding and spreading. The meter of the 29.2 isobar which was the inner isobar at this e had diminished from 175 miles at 5 a. m. to 110 miles at a. m., a total decrease of 65 miles. A very slow filling up was progress, for the other isobars throughout the cyclonic area l contracted in about the same proportion as the 29.2 isobar. Pressure distribution at 11 p. m., August 17th, 12 hours later n the preceding map is shown in Figure 11. The storm at s time was curving to the eastward and advancing slowly, the rate of about 8 miles per hour, just a little more than f the speed with which it had advanced during the first nine rs after it moved inland. There are no pressure records r the cyclonic center and the lowest isobar which can be wn accurately is 29.4 inches. This isobar diminished in meter 65 miles during the preceding 12 hours, from 200 miles 1 a. m., to 135 miles at 11 p. m., August 17th. The forms of 29.4 to 29.6 isobars remain nearly circular. There was some wding of the isobars in front and a decided spreading out or ge in the isobars in left rear quadrant outside of the 29.6 bar.

Figure 12 shows the cyclonic area at 11 a. m., August 18th, 12 rs later than the preceding map, and at the time when the

center of the cyclone was midway of the curve in the path alo which the cyclonic center advanced. The cyclone had advanc very slowly. The nearest isobar to the center, for which have data, is 29.5 inches. The diameter of this isobar h diminished 90 miles during the preceding 12 hours, from 1 miles at 11 p. m., August 17th, to 90 miles at 11 a. m., Augu 18th. The isobars within the 29.7 isobar were nearly circul Outside of the 29.7 isobar, there was a decided crowding of t isobars in the left front quadrant and a marked spreading o or bulge in the rear of the cyclone, showing a shifting of t crowding and spreading as the cyclone advanced and chang direction.

Pressure distribution at 8 a. m., August 19th, at which ti the cyclonic center had stopped curving and was moving towar the northeast, is shown in Figure 13. The isobars are crowd together in the left front quadrant and spread out causing bulge in the right rear quadrant. The crowding of the isob has changed from the right side to the left side of the cyclo area and the spreading of the isobars with the resultant bu has shifted from the left rear quadrant of the cyclonic area the right rear quadrant.

TROPICAL CYCLONE ON THE WEST GULF COAST, AUGUST 15 TO 18, 1915
3LE VII 90th Meridian Time

Corpus Christi, Texas. Latitude 27° 49′ N. Longitude 97° 25′ W. To the left of the line followed by the center of the cyclone, 165 miles.								Houston, Texas. Latitude 29° 47′ N. Longitude 95° 24′ W. To the right of the line followed by the center of the cyclone, 15 miles.							
DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS		DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION							KIND	DIRECTION
th								16th							
.m.	29.77	80	0	nw.	9			4 a.m.	29.71	82	0	ne.	16		
.m.	29.76	79	0	nw.	12			5 a.m.	29.68	80	0	n.	14		
.m.	29.74	79	0	n.	11			6 a.m.	29.69	81	0	n.	16		
.m.	29.73	79	0	n.	12			7 a.m.	29.69	80	T.	ne.	18	st. cu.	
.m.	29.72	79	0	nw.	15			8 a.m.	29.68	81	T.	ne.	21		
.m.	29.72	80	0	nw.	15	ci.	ne.	9 a.m.	29.67	82	0	ne.	24		
.m.	29.73	81	0	nw.	16	ci. cu.	ne.	10 a.m.	29.65	83	0	ne.	24		
.m.	29.73	82	T.	n.	17	a. st.	ne.	11 a.m.	29.64	84	0	ne.	25		
.m.	29.72	84	0	n.	21			12 noon	29.62	82	T.	ne.	24		
.m.	29.69	87	0	n.	23	a. st.	ne.	1 p.m.	29.61	75	.04	ne.	21		
.m.	29.66	88	0	n.	29			2 p.m.	29.57	77	.05	ne.	23		
noon	29.63	89	0	n.	28			3 p.m.	29.53	75	.07	n.	25		
.m.	29.62	90	0	n.	30	a. st.	n.	4 p.m.	29.49	75	.07	ne.	29		
.m.	29.58	93	0	n.	29	st. cu.	n.	5 p.m.	29.47	74	.15	ne.	30		
.m.	29.55	94	0	n.	30	a. st.	n.	6 p.m.	29.42	74	.22	n.	31		
.m.	29.53	88	T.	n.	31	st. cu.	n.	7 p.m.	29.38	74	.22	n.	34	st.	s.
.m.	29.52	88	0	n.	27			8 p.m.	29.32	74	.28	ne.	38		
.m.	29.52	85	T.	nw.	30			9 p.m.	29.26	74	.31	ne.	39		
.m.	29.51	87	0	nw.	27	a. st.	n.	10 p.m.	29.17	73	.67	ne.	46		
.m.	29.51	87	0	nw.	29	st. cu.	n.	11 p.m.	29.07	73	.76	ne.	48		
.m.	29.54	86	0	nw.	31			12 mid.	28.95	73	1.11	ne.	50		
.m.	29.54	85	0	nw.	26			17th							
.m.	29.51	85	0	nw.	27			1 a.m.	28.88	73	.85	ne.	44		
nid.	29.49	84	0	nw.	28			2 a.m.	28.78	74	.36	ne.	39		
'th								3 a.m.	28.61	74	.30	ne.	45		
a.m.	29.48	84	0	nw.	28			4 a.m.	28.36	73	.80	ne.	57		
) am	29.48	C	en	ter	Pass	ed		5 a.m.	28.25	72	.76	se.	74		
a.m.	29.48	84	0	nw.	28			5:25 am	28.20	C	ente	r P	asse	d	
a.m.	29.48	84	0	nw.	26			6 a.m.	28.50	72	.20	se.	80		
a.m.	29.49	85	0	nw.	20			7 a.m.	28.72	72	.07	se.	64	a. st.	ne.
a.m.	29.50	85	0	w.	19			8 a.m.	28.90	71	.02	se.	49		
a.m.	29.51	85	0	sw.	19			9 a.m.	29.02	72	.21	se.	43		
a.m.	29.54	85	0	w.	19	st. cu.	nw.	10 a.m.	29.10	73	.03	se.	40		
a.m.	29.55	86	0	w.	22			11 a.m.	29.19	72	T.	s.	39		
a.m.	29.58	87	0	w.	22			12 noon	29.24	71	T.	s.	37		
a.m.	29.59	88	0	w.	22			1 p.m.	29.30	71	.01	s.	37		

TROPICAL CYCLONE ON THE WEST GULF COAST, AUGUST 15 TO 18, 1915
TABLE VII 90th Meridian Time

Corpus Christi, Texas. Latitude 27° 49′ N. Longitude 97° 25′ W. To the left of the line followed by the center of the cyclone, 165 miles.								Houston, Texas. Latitude 29° 47′ N. Longitude 95° 24′ To the right of the line followed by t center of the cyclone, 15 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOU	
						Kind	Direction							Kind	
17th								17th							
11 a.m.	29.60	89	0	w.	21			2 p.m.	29.34	73	T.	s.	37		
12 noon	29.60	90	0	w.	20			3 p.m.	29.40	71	.01	s.	30		
1 p.m.	29.63	89	0	nw.	19			4 p.m.	29.44	74	.02	s.	30		
2 p.m.	29.63	87	0	nw.	19			5 p.m.	29.46	73	T.	s.	27		
3 p.m.	29.61	92	0	sw.	12			6 p.m.	29.49	74	T.	s.	22		
4 p.m.	29.60	97	0	sw.	15			7 p.m.	29.54	72	T.	s.	22		
5 p.m.	29.60	97	0	sw.	12			8 p.m.	29.55	73	.02	s.	20		
6 p.m.	29.61	90	0	nw.	13	ci.	w.	9 p.m.	29.59	75	T.	s.	18		
7 p.m.	29.63	90	0	nw.	6	ci. st.	w.	10 p.m.	29.60	74	0	s.	18		
8 p.m.	29.65	89	0	nw.	4	a. st.	w.	11 p.m.	29.60	74	0	s.	14		
9 p.m.	29.68	86	0	s.	3			12 mid.	29.60	74	0	s.	14		
10 p.m.	29.71	85	0	s.	4			18th							
11 p.m.	29.71	86	0	w.	3			1 a.m.	29.60	77	0	s.	14		
12 mid.	29.71	85	0	w.	1			2 a.m.	29.61	77	0	s.	14		
18th								3 a.m.	29.61	77	0	s.	13		
1 a.m.	29.71	84	0	w.	3			4 a.m.	29.63	76	0	sw.	13		
2 a.m.	29.71	84	0	s.	9			5 a.m.	29.65	76	0	s.	13		
3 a.m.	29.71	83	0	sw.	8			6 a.m.	29.65	76	0	s.	11		
4 a.m.	29.71	80	0	s.	10			7 a.m.	29.68	78	0	s.	10	nb.	
5 a.m.	29.72	80	0	s.	10			8 a.m.	29.69	84	0	s.	12		
6 a.m.	29.74	80	0	sw.	9			9 a.m.	29.70	82	0	s.	17		
7 a.m.	29.76	79	0	s.	10	ci.	sw.	10 a.m.	29.70	86	0	s.	16		
8 a.m.	29.77	85	0	sw.	9	st. cu.	s.	11 a.m.	29.70	85	0	s.	18		
9 a.m.	29.77	87	0	sw.	10			12 noon	29.70	88	0	s.	19		
10 a.m.	29.76	92	0	sw.	11	ci.	sw.	1 p.m.	29.70	89	0	s.	22		
11 a.m.	29.75	94	0	sw.	12	ci. cu.	sw.	2 p.m.	29.70	88	0	s.	22		
						st. cu.	sw.								

TROPICAL CYCLONE ON THE WEST GULF COAST, AUGUST 15 TO 18, 1915
LE VII 90th Meridian Time

Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 45 miles.								New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 250 miles.							
	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction	Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
h								15th							
m.	29.65	80	0	n.	32			12 noon	29.90	83	0	ne.	13		
m.	29.64	80	0	n.	29			1 p.m.	29.88	83	0	ne.	18	a. st.	ne.
m.	29.63	79	0	n.	30	st.	ne.	2 p.m.	29.86	83	0	ne.	17		
m.	29.62	80	0	n.	30			3 p.m.	29.84	83	0	ne.	16	st.	ne.
m.	29.61	80	0	ne.	34			4 p.m.	29.84	82	T.	ne.	13		
m.	29.60	80	T.	ne.	36	st.	ne.	5 p.m.	29.83	82	T.	ne.	10		
m.	29.58	76	.06	ne.	35			6 p.m.	29.82	80	T.	ne.	11		
oon	29.54	74	.05	n.	38			7 p.m.	29.81	75	.18	ne.	16	nb.	ne.
n.	29.51	73	.24	n.	45	st.	ne.	8 p.m.	29.81	78	T.	ne.	15		
n.	29.45	73	.25	n.	48			9 p.m.	29.80	79	0	ne.	16		
n.	29.37	73	.20	ne.	47	st.	ne.	10 p.m.	29.80	79	0	ne.	17		
n.	29.28	73	.15	ne.	60			11 p.m.	29.79	80	0	ne.	18		
n.	29.23	73	.66	ne.	55			12 mid.	29.79	80	.01	e.	23		
n.	29.16	74	.49	ne.	53			16th							
n.	29.09	73	.67	ne.	62	st.	ne.	1 a.m.	29.76	80	T.	e.	23		
n.	29.02	73	.14	ne.	62			2 a.m.	29.76	80	.37	e.	24		
n.	28.90	76		ne.	62			3 a.m.	29.75	78	.02	e.	23		
n.	28.80	76		ne.	71			4 a.m.	29.75	78	.06	e.	22		
n.	28.75	77		e.	73			5 a.m.	29.76	79	0	e.	21		
d.	28.69	76		e.	68			6 a.m.	29.77	79	0	e.	22		
h								7 a.m.	29.77	73	.49	se.	19	nb.	se.
n.	28.67	75		e.	73			8 a.m.	29.78	75	.13	se.	18		
n.	28.64	75		e.	81	Center		9 a.m.	29.79	79	.02	se.	17		
n.	28.68	76		e.	80	Passed		10 a.m.	29.79	81	.02	se.	18	st.	se.
n.	28.78	77		se.	72			11 a.m.	29.79	82	.02	se.	17		
n.	28.89	76		se.	63			12 noon	29.79	84	0	se.	20	st.	se.
n.	29.03	75		se.	55			1 p.m.	29.79	86	0	se.	21		
n.	29.16	75		s.	53	st.	s.	2 p.m.	29.79	85	0	se.	20		
n.	29.25	73		s.	55			3 p.m.	29.78	85	0	se.	20	st.	se.
n.	29.29	72		s.	48			4 p.m.	29.77	85	0	se.	17		
n.	29.34	72		s.	51			5 p.m.	29.75	84	0	se.	16	Center	
n.	29.40	72		s.	47			6 p.m.	29.77	84	0	se.	17	Passed	
oon	29.44	78		s.	41			7 p.m.	29.79	83	0	se.	16	a. st.	se.
n.	29.49	79		s.	37			8 p.m.	29.82	82	0	se.	15	st.	se.
n.	29.53	77		s.	35			9 p.m.	29.83	82	0	se.	15		
n.	29.55	78		s.	34			10 p.m.	29.84	82	0	se.	15		

** Automatic Precipitation Recorder Failed after 8 p. m.

TROPICAL CYCLONE ON THE WEST GULF COAST, AUGUST 15 TO 18, 1915

TABLE VII 90th Meridian Time

Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 45 miles.								New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 250 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
17th								16th							
4 p.m.	29.56	80		s.	36			11 p.m.	29.86	82	0	se.	15		
5 p.m.	29.56	83		s.	35			12 mid.	29.86	81	0	se.	15		
6 p.m.	29.58	81		s.	32	a. st.	sw.	17th							
7 p.m.	29.61	82		s.	26	cu. nb.	s.	1 a.m.	29.84	81	0	se.	15		
8 p.m.	29.63	73		s.	23	st.	s.	2 a.m.	29.84	81	0	se.	16		
9 p.m.	29.66	72		s.	24			3 a.m.	29.85	79	0	se.	14		
10 p.m.	29.66	73		s.	26			4 a.m.	29.84	81	.01	se.	14		
11 p.m.	29.66	79		s.	28			5 a.m.	29.84	81	0	se.	15		
12 mid.	29.67	80		s.	33			6 a.m.	29.86	81	0	se.	14		
18th								7 a.m.	29.88	81	0	se.	13	st.	se.
1 a.m.	29.68	82		s.	34			8 a.m.	29.89	82	0	se.	14		
2 a.m.	29.68	81		s.	29			9 a.m.	29.89	84	0	se.	18		
3 a.m.	29.69	78		s.	25			10 a.m.	29.92	85	0	se.	20		
4 a.m.	29.70	73		s.	16			11 a.m.	29.91	86	0	se.	22		
5 a.m.	29.71	78		s.	25			12 noon	29.91	87	0	se.	21	st. cu.	s.
6 a.m.	29.72	81		s.	32	cu.	s.	1 p.m.	29.90	88	0	s.	21		
7 a.m.	29.74	82		s.	30	st.	s.	2 p.m.	29.90	88	0	s.	19		
8 a.m.	29.75	82		s.	29			3 p.m.	29.90	87	0	s.	18		
9 a.m.	29.76	83		s.	33			4 p.m.	29.90	86	0	s.	16		
10 a.m.	29.77	83		s.	29			5 p.m.	29.90	86	T.	s.	14		
11 a.m.	29.78	84		s.	30			6 p.m.	29.91	86	0	s.	14	ci. st.	w.
12 noon	29.79	84		s.	31			7 p.m.	29.91	83	0	s.	11	cu.	sw.
1 p.m.	29.77	84		s.	30			8 p.m.	29.93	82	0	s.	8		
2 p.m.	29.75	84		s.	28			9 p.m.	29.93	81	0	se.	8		
3 p.m.	29.74	84		s.	28			10 p.m.	29.93	80	0	se.	7		
4 p.m.	29.73	83		s.	29			11 p.m.	29.93	80	0	se.	7		
			**Automatic Precipitation Recorder Failed after 8 p. m.												

LE VII-a

ERVED BAROMETER READINGS AT VELASCO, TEXAS, AUGUST 16-17, 1915. SUP-IENTAL TO TABLE VIII. 90TH MERIDIAN TIME. (BAROMETER COMPARED AND ORMAL PRESSURES READS WITHIN .08 INCH OF THE MERCURIAL.)

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	WIND DIRECTION	DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	WIND DIRECTION
16th					
:20 p.m.	29.40	ne.	10:00 p.m.	28.66	n.
:00 p.m.	29.38	ne.	10:20 p.m.	28.60	n.
:20 p.m.	29.36	ne.	10:30 p.m.	28.56	n.
:45 p.m.	29.34	ne.	10:50 p.m.	28.50	n.
:15 p.m.	29.30	ne.	11:10 p.m.	28.48	n.
:30 p.m.	29.28	ne.	11:30 p.m.	28.40	n.
:45 p.m.	29.24	ne.	11:45 p.m.	28.34	n.
:15 p.m.	29.22	ne.	12:00 mid.	28.28	n.
:30 p.m.	29.20	n.	17th		
:00 p.m.	29.18	n.	12:15 a.m.	28.24	n.
:30 p.m.	29.14	n.	12:25 a.m.	28.18	n.
:10 p.m.	29.12	n.	1:00 a.m.	28.14	nw.
:40 p.m.	29.08	n.	1:30 a.m.	28.18	nw.
:00 p.m.	29.06	n.	1:50 a.m.	28.30	nw.
:20 p.m.	29.02	n.	2:15 a.m.	28.40	nw.
:45 p.m.	28.98	n.	2:30 a.m.	28.45	w.
:10 p.m.	28.94	n.	2:45 a.m.	28.50	w.
:50 p.m.	28.90	n.	3:15 a.m.	28.60	w.
:15 p.m.	28.82	n.	3:40 a.m.	28.70	w.
:25 p.m.	28.80	n.	7:15 a.m.	29.20	sw.
:40 p.m.	28.74	n.	12:40 p.m.	29.40	sw.

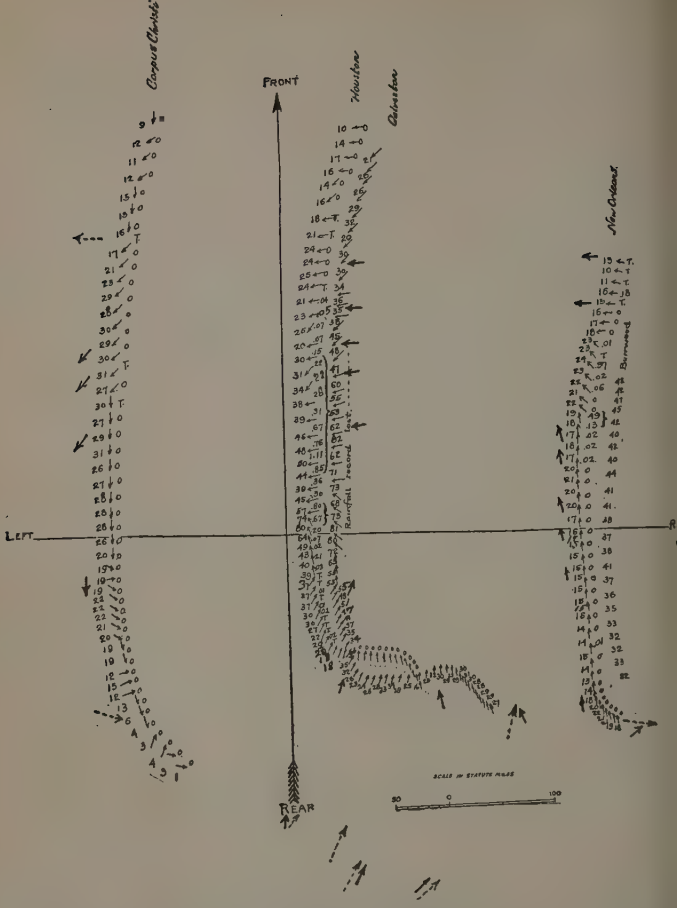


Figure 8. Records made during the passage of the tropical cyclone, Au
16-18, 1915. Intersection of cross lines represents the center of the cyclone. Po
of small regular arrows rest on positions of stations at the time the records
made; figures on the left of the arrows are wind velocities in miles per hour;
figures on the right of the arrows are the hourly precipitation measured to hundre
of an inch. Brackets show the greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of the larger traveling cyclones.

OPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

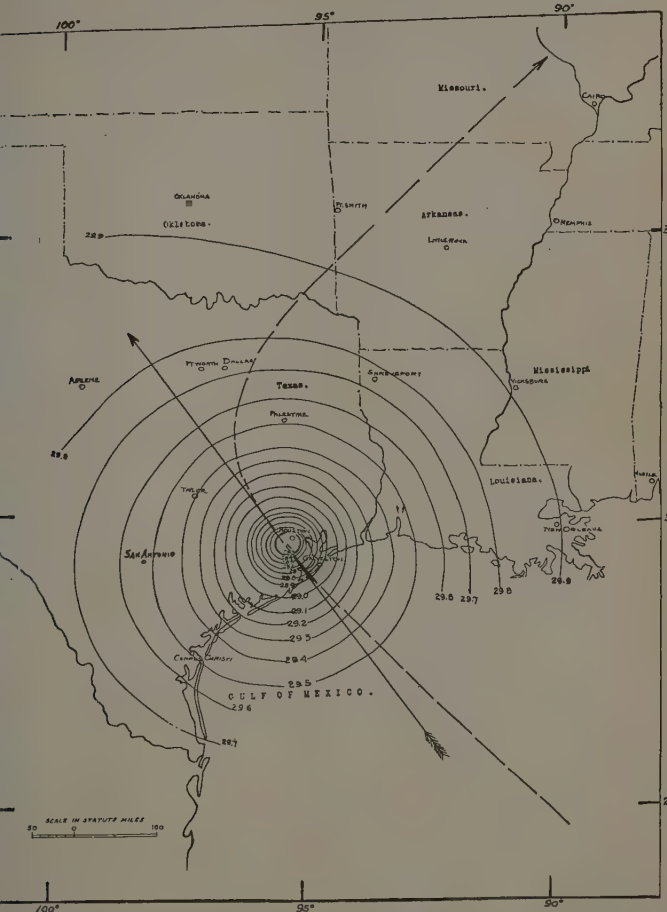


Figure 9. 5:00 a.m., August 17, 1915, 75th Meridian Time. Distribution of ssure. Isobars are drawn for each .10 of an inch. Broken line is path followed the cyclone.
The line with arrow indicates the direction of movement of the cyclone at 5:00 a.m.

Tropical Cyclones in the Gulf and Caribbean Regions —*Cline.*

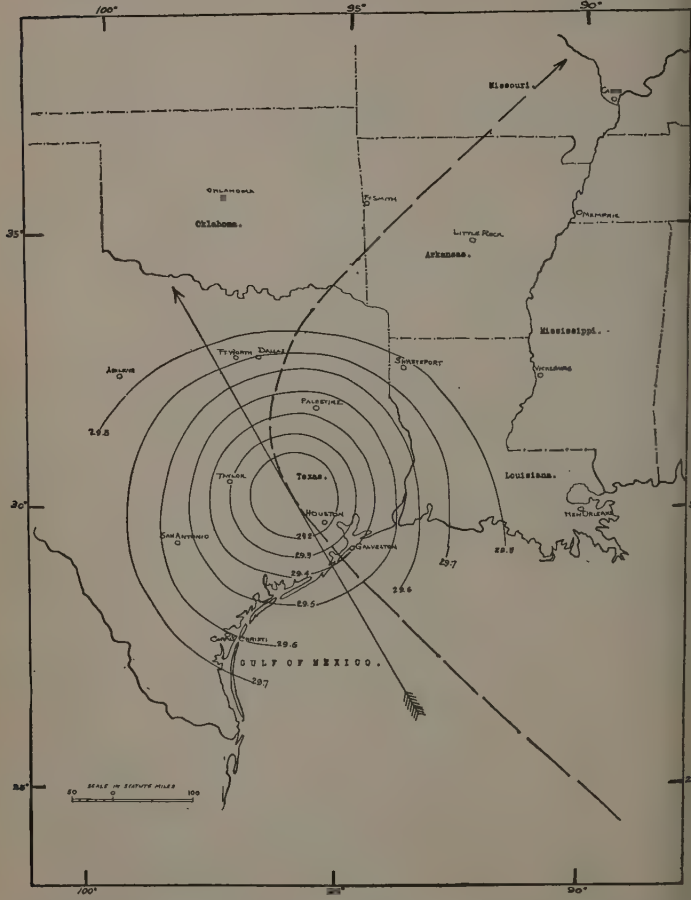


Figure 10. Distribution of pressure, 11:00 a.m., August 17, 1915, 75th Merid Time. Isobars are drawn for each .10 of an inch. Broken line is path followed the cyclone.

The line with arrow indicates the direction of movement of the cyclonic cen at 11:00 a.m.

ROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

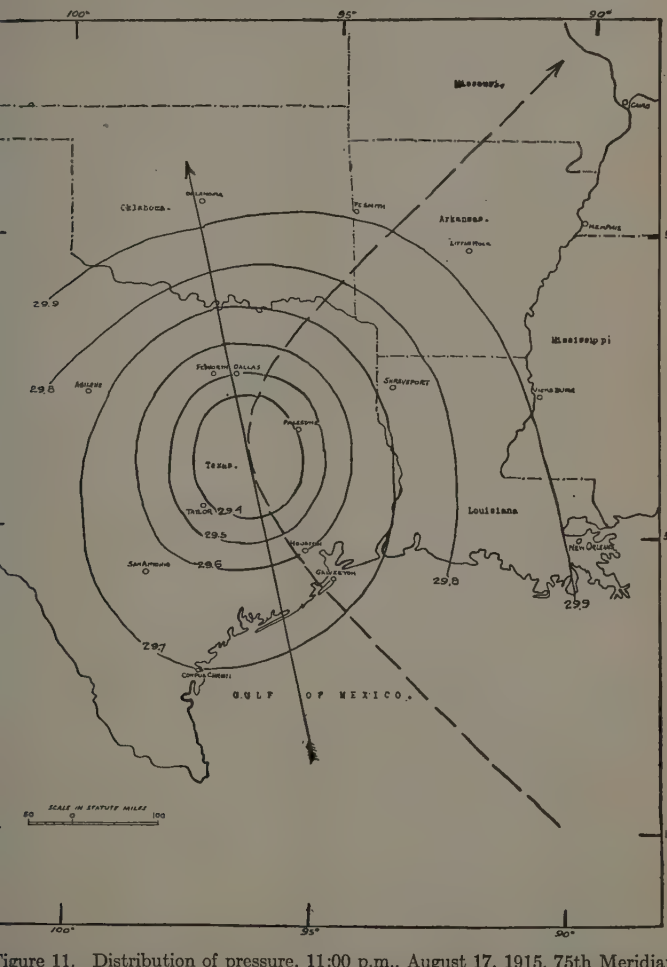


Figure 11. Distribution of pressure, 11:00 p.m., August 17, 1915, 75th Meridian time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclone.
The line with arrow indicates the direction of movement of the cyclonic center at 8:00 p.m.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

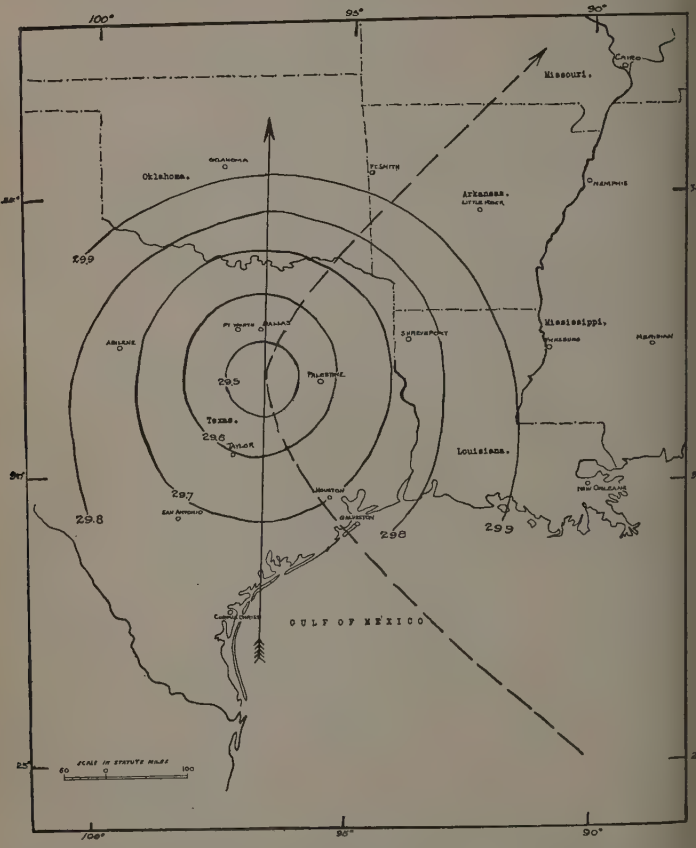


Figure 12. Distribution of pressure, 11:00 a.m., August 18, 1915, 75th Meridia Time. Isobars are drawn for each .10 of an inch. Broken line is path followe by the cyclone.

The line with arrow indicates the direction of movement of the cyclonic cent at 11:00 a.m.

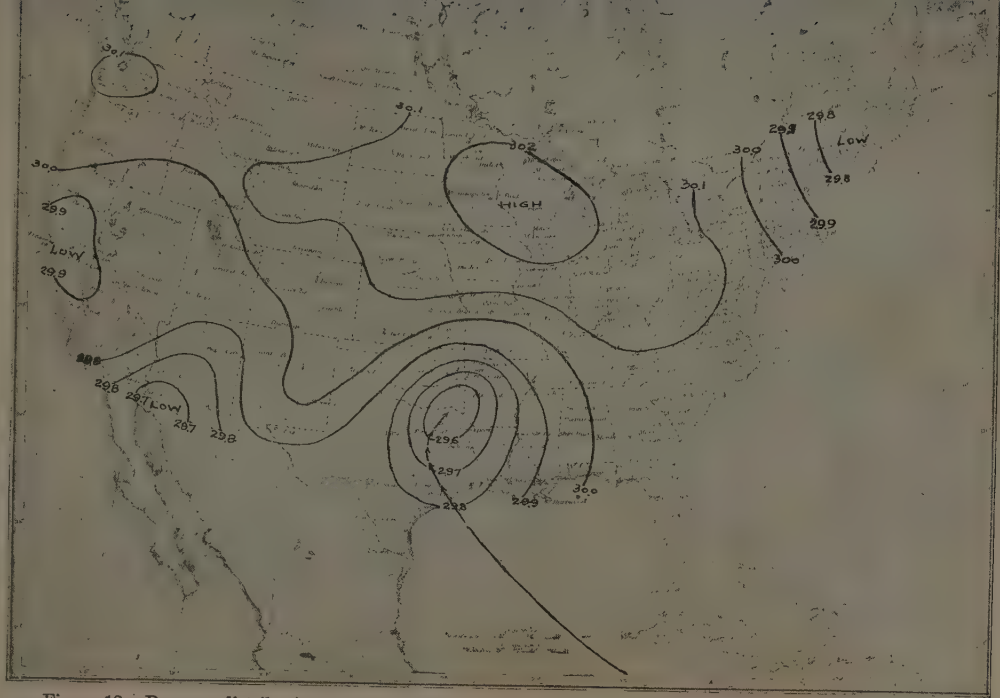


Figure 13. Pressure distribution, 8 a.m., August 19, 1915, 75th Meridian Time, during the passage of a tropical

VIII

ɔpical Cyclone While Passing Over Central Mississippi Valley August 19-21, 1915

The cyclone at 8 a. m., August 20th, when it was centered r southeastern Missouri is shown in Figure 14. Here the ɔars near the center have increased in diameter after having dually decreased in diameter during the preceding three days. *e 29.5 isobar had increased in diameter to 180 miles, double diameter of the same isobar at 11 a. m., August 18th,* two rs previously, when the storm was midway of the curve of path followed by the center. The 29.7 isobar, however, ained about the same diameter and form as that at 11 a. m., gust 18th. The isobars at this time were crowded together in left front quadrant and spread out causing a bulge in the nt rear quadrant.

The increase in the intensity of this cyclone while traveling r the central Mississippi Valley and the occurrence of excese precipitation nearly as heavy as that recorded when the lone first moved in on the Texas Coast, makes a study of the ditions in the cyclonic area at this time of special importance ause the cyclone has advanced far into extra-tropical regions. e detailed meteorological data recorded at eight stations, four the right and four on the left of the line followed by the lonic center, are given in Table VIII. The relations of the ds and precipitation to the cyclonic center and its direction movement are charted in Figure 15. In the right front adrant the winds have about the same inclination towards the ter of the cyclone as found when the cyclone moved in on the lf Coast. In the left front quadrant they are inclined more ard the center and move back almost directly opposed to line of advance. In the left rear quadrant directions are newhat across the line of advance of the cyclone. In the right r quadrant the winds have the same general direction as that which the cyclone was traveling, the same as found on the f Coast and in the Florida Straits. Heavy precipitation urred in the front and the right front quadrant, but with the

passage of the cyclonic center the precipitation fell off rapidly at all stations and soon ceased altogether.

At St. Louis, Mo., 40 miles to the left of the line followed by the center, the rainfall was continuously heavy for fourteen hours before the passage of the center; the total rainfall before the passage of the center was 6.51 inches and only .88 of an inch fell after the passage of the center. At Cairo, Ill., 60 miles to the right of the center, the rainfall was 2.43 inches before the passage of the center and .05 inch after the passage of the center. At Memphis, Tenn., 110 miles to the right of the center, 4.2 inches fell before the passage of the center and .05 inch after the center had passed. At Springfield, Mo., 80 miles to the left of the center, there was 3.15 inches before and .29 of an inch after the passage of the center.

The lower clouds changed direction in several instances before the winds changed to the same directions. No upper clouds were recorded in the front of the cyclonic area and those recorded in the rear were from the west and southwest, having the same direction as the prevailing air current of that region.

On the morning of August 21st, the cyclone had diminished in intensity as shown in Figure 16. The lowest isobar which could be drawn to a pressure reading was 29.6; during the preceding 24 hours this isobar had decreased in diameter about 6 miles, from 285 miles at 8 a. m., August 20th, to 225 miles at 8 a. m., August 21st. The isobars were then crowded in the front half and spread out showing a bulge in the right rear quadrant of the cyclonic area. The storm continued to diminish in intensity as it traveled towards the northeast, as is shown on Figure 17, 8 a. m., August 22, 1915. Here the isobars spread out in the right rear quadrant of the cyclonic area towards the region of heavy precipitation which resulted from the air being drawn over mountain ranges.

Figure 14.—Pressure distribution, 8 a.m., August 20, 1915, 75th Meridian Time, during the passage of a tropical

TROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

BLE VIII 90th Meridian Time

Kansas City, Missouri. Latitude 39° 05′ N. Longitude 94° 37′ W. To the left of the line followed by the center of the cyclone, 225 miles.								Hannibal, Missouri. Latitude 39° 41′ N. Longitude 91° 20′ W. To the left of the line followed by the center of the cyclone, 150 miles.							
DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS		DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION							KIND	DIRECTION
9th								19th							
a.m.		64	0	ne.	12			1 a.m.	30.09	66	0	ne.	7		
a.m.		64	0	ne.	12			2 a.m.	30.08	65	0	ne.	9		
a.m.		64	0	ne.	11			3 a.m.	30.07	64	0	ne.	9		
a.m.		63	0	ne.	13			4 a.m.	30.08	63	0	ne.	8		
a.m.		63	0	ne.	12			5 a.m.	30.09	63	0	ne.	10		
a.m.		63	.05	ne.	14			6 a.m.	30.09	62	0	ne.	11		
a.m.	30.03	62	T.	ne.	15	nb.	ne.	7 a.m.	30.09	61	0	ne.	11	st. cu.	ne.
a.m.		62	T.	ne.	15			8 a.m.	30.09	60	0	ne.	11		
a.m.		62	T.	ne.	15			9 a.m.	30.08	63	0	ne.	13		
a.m.	30.04	63	0	ne.	15			10 a.m.	30.08	66	0	ne.	17		
a.m.		66	0	ne.	16			11 a.m.	30.07	68	0	ne.	18		
noon	30.00	67	0	ne.	18			12 noon	30.06	70	0	ne.	16		
p.m.		69	0	ne.	20			1 p.m.	30.04	72	0	ne.	15		
p.m.	29.95	72	0	ne.	22			2 p.m.	30.03	73	0	ne.	15		
p.m.		72	0	ne.	19			3 p.m.	30.02	73	0	ne.	15		
p.m.	29.93	72	0	ne.	20	st. cu.	ne.	4 p.m.	30.01	73	0	ne.	15		
p.m.		71	0	ne.	19			5 p.m.	29.99	72	0	ne.	14		
p.m.	29.92	70	0	ne.	14			6 p.m.	29.97	71	0	ne.	11		
p.m.		69	0	ne.	19	st. cu.	ne.	7 p.m.	29.96	70	0	ne.	9		
p.m.	29.92	69	0	ne.	17			8 p.m.	29.95	69	0	ne.	10		
p.m.		68	0	ne.	20			9 p.m.	29.94	68	0	ne.	11		
p.m.	29.92	68	0	ne.	20			10 p.m.	29.93	67	0	ne.	11		
p.m.		67	0	ne.	16			11 p.m.	29.92	67	0	ne.	8		
mid.	29.90	66	0	n.	14			12 mid.	29.90	66	0	ne.	7		
0th								20th							
a.m.		65	0	n.	14			1 a.m.	29.86	65	0	ne.	11		
a.m.	29.86	64	0	n.	14			2 a.m.	29.84	64	0	ne.	12		
a.m.		63	0	n.	13			3 a.m.	29.82	62	.02	ne.	11		
a.m.	29.85	62	0	n.	13			4 a.m.	29.79	60	.06	ne.	11		
a.m.		61	0	n.	13			5 a.m.	29.77	59	.06	n.	11		
a.m.	29.85	61	0	n.	13			6 a.m.	29.76	59	.10	n.	13		
a.m.		60	0	n.	14	a. st.	nw.	7 a.m.	29.75	58	.10	n.	15	nb.	n.
a.m.	29.87	61	0	n.	18			8 a.m.	29.75	58	.14	n.	13		
a.m.		63	0	n.	15			9 a.m.	29.74	58	.15	n.	14		
a.m.	29.88	66	0	n.	20			10 a.m.	29.73	57	.10	n.	15		
a.m.		68	0	n.	21	Center		11 a.m.	29.71	58	.07	n.	15		
noon	29.85	69	0	n.	22	Passed		12 noon	29.70	57	.05	n.	17		

TROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

TABLE VIII 90th Meridian Time

Kansas City, Missouri. Latitude 39° 05′ N. Longitude 94° 37′ W. To the left of the line followed by the center of the cyclone, 225 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
20th							
1 p.m.		71	0	n.	24		
2 p.m.	29.84	73	0	n.	23		
3 p.m.		73	0	n.	22		
4 p.m.	29.84	74	0	n.	19		
5 p.m.		74	0	n.	20		
6 p.m.	29.85	73	0	n.	17		
7 p.m.		71	0	n.	14	ci. st.	nw.
8 p.m.	29.88	69	0	n.	11		
9 p.m.		68	0	n.	11		
10 p.m.	29.90	66	0	n.	6		
11 p.m.		65	0	n.	6		
12 mid.	29.90	64	0	n.	6		
21st							
1 a.m.		62	0	n.	5		
2 a.m.	29.90	62	0	n.	6		
3 a.m.		60	0	nw.	6		
4 a.m.	29.90	59	0	w.	7		
5 a.m.		59	0	w.	8		
6 a.m.	29.92	58	0	w.	10		
7 a.m.		58	0	w.	7	Cloudless	
8 a.m.	29.94	63	0	w.	7		
9 a.m.		69	0	w.	8		
10 a.m.	29.96	74	0	nw.	11		
11 a.m.		77	0	nw.	10		
12 noon	29.94	78	0	nw.	8		
1 p.m.		80	0	n.	8		
2 p.m.	29.95	81	0	nw.	7		
3 p.m.		81	0	nw.	7		
4 p.m.	29.92	81	0	n.	8		
5 p.m.		80	0	n.	8		
6 p.m.	29.91	79	0	nw.	6		
7 p.m.		77	0	nw.	5	ci.	w.
8 p.m.	29.92	75	0	nw.	4		
9 p.m.		73	0	nw.	1		
10 p.m.	29.92	72	0	0	0		
11 p.m.		70	0	nw.	1		
12 mid.	29.92	70	0	nw.	1		

Hannibal, Missouri. Latitude 39° 41′ N. Longitude 91° 20′ W. To the left of the line followed by the center of the cyclone, 150 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
20th							
1 p.m.	29.70	58	.01	n.	18		
2 p.m.	29.69	58	.06	n.	23		
3 p.m.	29.69	60	.05	n.	17		
4 p.m.	29.69	62	.07	n.	11		
5 p.m.	29.69	62	.04	n.	14	Center	
6 p.m.	29.70	62	.04	n.	16	Passed	
7 p.m.	29.71	63	.06	n.	16		
8 p.m.	29.71	63	T.	n.	11		
9 p.m.	29.72	64	0	nw.	10		
10 p.m.	29.73	64	0	nw.	11		
11 p.m.	29.74	64	0	nw.	12		
12 mid.	29.75	64	0	nw.	13		
21st							
1 a.m.	29.76	64	0	nw.	14		
2 a.m.	29.77	64	0	nw.	13		
3 a.m.	29.78	63	0	nw.	13		
4 a.m.	29.79	62	0	nw.	9		
5 a.m.	29.80	61	0	nw.	9		
6 a.m.	29.81	61	0	nw.	9		
7 a.m.	29.84	61	0	nw.	8		
8 a.m.	29.86	62	0	nw.	8	a. st.	nw
9 a.m.	29.86	65	0	nw.	9		
10 a.m.	29.87	70	0	nw.	10		
11 a.m.	29.88	73	0	nw.	9		
12 noon	29.91	74	0	nw.	10		
1 p.m.	29.91	76	0	nw.	9		
2 p.m.	29.90	77	0	nw.	8		
3 p.m.	29.90	78	0	nw.	8		
4 p.m.	29.90	78	0	nw.	9		
5 p.m.	29.88	78	0	nw.	8		
6 p.m.	29.87	78	0	nw.	4		
7 p.m.	29.88	73	0	nw.	4		
8 p.m.	29.90	66	0	sw.	5		
9 p.m.	29.91	65	0	sw.	6		
10 p.m.	29.93	63	0	sw.	7		
11 p.m.	29.92	62	0	sw.	7		
12 mid.	29.92	61	0	sw.	7		

TROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

BLE VIII 90th Meridian Time

Springfield, Missouri. Latitude 37° 12′ N. Longitude 93° 18′ W. To the left of the line followed by the center of the cyclone, 95 miles.								Saint Louis, Missouri. Latitude 38° 38′ N. Longitude 90° 12′ W. To the left of the line followed by the center of the cyclone, 40 miles.							
DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS		DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION							KIND	DIRECTION
th								19th							
.m.	29.97	67	.02	e.	7			1 a.m.	30.07	63	0	e.	8		
.m.	29.96	67	.04	e.	12			2 a.m.	30.05	63	0	e.	8		
.m.	29.95	67	.02	e.	8			3 a.m.	30.04	63	0	e.	10		
.m.	29.93	67	.01	e.	7			4 a.m.	30.04	63	0	e.	11		
.m.	29.93	67	.01	e.	8			5 a.m.	30.05	63	0	e.	10		
.m.	29.92	67	.07	e.	7			6 a.m.	30.05	63	0	ne.	10		
.m.	29.92	66	.12	e.	11	nb.	e.	7 a.m.	30.05	63	0	e.	10	st.	e.
.m.	29.92	66	.03	e.	12			8 a.m.	30.04	63	0	e.	9		
.m.	29.91	67	.04	ne.	13			9 a.m.	30.03	64	0	e.	10		
.m.	29.89	67	.06	e.	13			10 a.m.	30.03	65	0	e.	11		
.m.	29.87	66	.12	ne.	15			11 a.m.	30.02	68	0	ne.	13		
oon	29.82	65	.12	ne.	15	nb.	e.	12 noon	30.01	68	0	ne.	11		
.m.	29.81	66	.06	ne.	16			1 p.m.	30.00	67	0	e.	9	st.	e.
.m.	29.80	65	.09	ne.	17			2 p.m.	29.99	66	.01	e.	12		
.m.	29.77	65	.07	ne.	18			3 p.m.	29.98	65	.02	e.	9		
.m.	29.77	64	.21	ne.	20			4 p.m.	29.97	64	.01	e.	12		
.m.	29.75	64	.19	ne.	18			5 p.m.	29.93	63	T.	e.	12		
.m.	29.74	63	.25	ne.	19			6 p.m.	29.93	64	T.	e.	14		
.m.	29.71	62	.21	ne.	17	nb.	ne.	7 p.m.	29.91	64	.01	e.	16	st. cu.	se.
.m.	29.71	61	.17	ne.	18			8 p.m.	29.91	63	.01	e.	17		
.m.	29.71	61	.42	ne.	18			9 p.m.	29.91	63	.07	e.	16		
.m.	29.71	62	.35	ne.	20			10 p.m.	29.88	62	.12	e.	16		
.m.	29.70	61	.25	ne.	19			11 p.m.	29.86	61	.10	e.	18		
id.	29.68	61	.11	ne.	17			12 mid.	29.82	61	.09	e.	18		
th								20th							
.m.	29.67	60	.04	n.	17			1 a.m.	29.78	61	.09	e.	22		
.m.	29.66	60	.04	n.	19			2 a.m.	29.74	61	.22	e.	25		
.m.	29.65	60	.01	n.	20			3 a.m.	29.67	62	.39	ne.	29		
.m.	29.64	60	.02	n.	21	Center		4 a.m.	29.63	62	.50	ne.	37		
.m.	29.65	60	.01	n.	20	Passed		5 a.m.	29.59	62	.55	ne.	41		
.m.	29.65	60	.01	nw.	21			6 a.m.	29.54	62	.49	ne.	45		
.m.	29.66	60	.01	nw.	21	nb.	nw.	7 a.m.	29.50	62	.54	ne.	44	nb.	ne.
.m.	29.68	60	.05	nw.	23			8 a.m.	29.47	61	.49	ne.	37		
.m.	29.70	60	.07	nw.	21			9 a.m.	29.44	62	.41	ne.	42		
.m.	29.72	58	.04	nw.	19			10 a.m.	29.42	62	.49	ne.	40		
.m.	29.73	58	.06	nw.	21			11 a.m.	29.39	62	.41	ne.	41		
oon	29.74	58	.02	nw.	19	nb.	nw.	12 noon	29.38	62	.33	ne.	32	nb.	ne.

TROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

TABLE VIII — 90th Meridian Time

Springfield, Missouri. Latitude 37° 12′ N. Longitude 93° 18′ W. To the left of the line followed by the center of the cyclone, 95 miles.								Saint Louis, Missouri. Latitude 38° 38′ N. Longitude 90° 12′ W To the left of the line followed by th center of the cyclone, 40 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
20th								20th							
1 p.m.	29.76	57	T.	nw.	19			1 p.m.	29.38	62	.10	ne.	26		
2 p.m.	29.77	58	0	nw.	20			2 p.m.	29.37	62	.44	ne.	23		
3 p.m.	29.79	62	0	nw.	20			3 p.m.	29.37	61	.63	nw.	24	Center	
4 p.m.	29.81	64	0	nw.	20			4 p.m.	29.40	60	.30	nw.	32	Passed	
5 p.m.	29.84	65	0	nw.	15			5 p.m.	29.42	59	.13	nw.	38		
6 p.m.	29.85	66	0	nw.	10			6 p.m.	29.46	59	.08	nw.	39		
7 p.m.	29.86	65	0	nw.	8	st. cu.	nw.	7 p.m.	29.51	59	.04	nw.	39	st. cu.	nw
8 p.m.	29.87	63	0	nw.	7			8 p.m.	29.54	60	T.	nw.	37		
9 p.m.	29.88	61	0	nw.	6			9 p.m.	29.56	60	T.	nw.	37		
10 p.m.	29.89	60	0	nw.	8			10 p.m.	29.59	60	.01	nw.	31		
11 p.m.	29.90	59	0	nw.	9			11 p.m.	29.61	60	.11	nw.	28		
12 mid.	29.89	58	0	nw.	6			12 mid.	29.64	60	.10	nw.	26		
21st								21st							
1 a.m.	29.90	56	0	nw.	5			1 a.m.	29.66	60	.03	nw.	23		
2 a.m.	29.90	55	0	nw.	6			2 a.m.	29.68	60	.03	nw.	23		
3 a.m.	29.90	54	0	nw.	6			3 a.m.	29.71	61	.01	nw.	23		
4 a.m.	29.91	53	0	nw.	5			4 a.m.	29.74	62	.01	nw.	22		
5 a.m.	29.93	53	0	nw.	7			5 a.m.	29.78	62	.02	nw.	21		
6 a.m.	29.95	53	0	nw.	7			6 a.m.	29.79	62	T.	nw.	15		
7 a.m.	29.96	56	0	nw.	6	Cloudl	ess	7 a.m.	29.81	61	.01	nw.	19	st.	nw
8 a.m.	29.97	58	0	nw.	7			8 a.m.	29.82	63	0	nw.	23		
9 a.m.	29.99	61	0	nw.	7			9 a.m.	29.82	66	0	nw.	17		
10 a.m.	30.00	65	0	nw.	10			10 a.m.	29.84	69	0	nw.	17		
11 a.m.	30.00	67	0	nw.	10			11 a.m.	29.87	72	0	nw.	16	ci. st.	w.
12 noon	30.00	69	0	nw.	9			12 noon	29.87	74	0	nw.	16		
1 p.m.	29.99	71	0	nw.	6			1 p.m.	29.87	76	0	nw.	17		
2 p.m.	29.98	72	0	nw.	8			2 p.m.	29.87	76	0	nw.	17		
3 p.m.	29.96	73	0	nw.	9			3 p.m.	29.87	78	0	nw.	15		
4 p.m.	29.95	74	0	w.	8			4 p.m.	29.87	77	0	nw.	14		
5 p.m.	29.95	75	0	w.	7			5 p.m.	29.87	77	0	nw.	12		
6 p.m.	29.94	75	0	w.	5			6 p.m.	29.87	76	0	nw.	11		
7 p.m.	29.94	72	0	w.	4			7 p.m.	29.89	74	0	nw.	6	st.	nw
8 p.m.	29.94	70	0	w.	5			8 p.m.	29.91	72	0	nw.	6		
9 p.m.	29.94	68	0	w.	2			9 p.m.	29.93	71	0	nw.	9		
10 p.m.	29.94	67	0	w.	2			10 p.m.	29.93	69	0	nw.	9		
11 p.m.	29.95	66	0	w.	2			11 p.m.	29.93	69	0	w.	10		
12 mid.	29.94	65	0	w.	2			12 mid.	29.93	69	0	w.	11		

ROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

BLE VIII 90th Meridian Time

Cairo, Illinois. Latitude 37° 00′ N. Longitude 89° 10′ W. The right of the line followed by the center of the cyclone, 60 miles.								Little Rock, Arkansas. Latitude 34° 45′ N. Longitude 92° 06′ W. To the right of the line followed by the center of the cyclone, 90 miles.							
	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
th								19th							
m.	30.00	69	.02	ne.	8			1 a.m.	29.86	72	.06	e.	10		
m.	29.98	68	.03	ne.	9			2 a.m.	29.84	72	T.	e.	11		
m.	29.97	68	.03	ne.	8			3 a.m.	29.83	72	.02	e.	9		
m.	29.98	68	.04	ne.	9			4 a.m.	29.81	72	.03	e.	10		
m.	29.98	68	.05	ne.	8			5 a.m.	29.79	73	.03	e.	10		
m.	29.99	68	.03	ne.	10			6 a.m.	29.77	74	.09	e.	15		
m.	29.99	67	.03	ne.	9	nb.	ne.	7 a.m.	29.76	74	.11	e.	17	nb.	e.
m.	30.00	67	.06	ne.	7			8 a.m.	29.75	74	.12	e.	20		
m.	29.98	68	.05	ne.	7			9 a.m.	29.73	73	.35	se.	21		
m.	29.96	69	.02	ne.	9			10 a.m.	29.71	73	.18	se.	22		
m.	29.95	69	.03	ne.	8			11 a.m.	29.70	73	.10	se.	22		
oon	29.94	70	.01	ne.	7			12 noon	29.68	74	.02	se.	23		
m.	29.94	70	.08	ne.	7	nb.	ne.	1 p.m.	29.66	76	.02	se.	24		
m.	29.92	71	.02	ne.	9			2 p.m.	29.63	74	.08	se.	20		
m.	29.91	71	.09	ne.	8			3 p.m.	29.61	74	.07	se.	17		
m.	29.89	71	.07	ne.	11			4 p.m.	29.59	75	.05	se.	17		
m.	29.87	70	.02	ne.	12			5 p.m.	29.57	74	.14	se.	14		
m.	29.84	69	.02	ne.	14			6 p.m.	29.54	74	.05	se.	16		
m.	29.82	69	.04	ne.	16	nb.	e.	7 p.m.	29.52	74	.06	s.	19	nb.	s.
m.	29.79	69	.02	ne.	18			8 p.m.	29.52	75	.10	s.	18		
m.	29.78	69	.04	ne.	18			9 p.m.	29.52	75	.01	s.	16		
m.	29.75	68	.12	ne.	18			10 p.m.	29.51	75	T.	s.	16		
m.	29.71	69	.25	ne.	20			11 p.m.	29.50	75	T.	s.	14		
id.	29.66	70	.17	ne.	23			12 mid.	29.49	75	T.	s.	14		
th								20th							
m.	29.59	72	.32	e.	22			1 a.m.	29.48	72	T.	sw.	13		
m.	29.55	72	.30	e.	26			2 a.m.	29.47	71	T.	sw.	16	Center	
m.	29.52	72	.14	e.	24			3 a.m.	29.47	70	T.	sw.	14	Passed	
m.	29.49	72	.25	e.	22			4 a.m.	29.48	69	.01	sw.	13		
m.	29.46	72	.16	se.	15			5 a.m.	29.52	68	T.	w.	16		
m.	29.45	72	.01	se.	15			6 a.m.	29.56	68	0	w.	17		
m.	29.43	73	T.	se.	15	nb.	se.	7 a.m.	29.58	69	0	w.	19	st. cu.	w.
m.	29.43	73	.01	s.	19			8 a.m.	29.60	69	0	w.	23		
m.	29.41	73	T.	s.	21			9 a.m.	29.62	69	0	w.	22		
m.	29.41	73	T.	s.	20			10 a.m.	29.66	72	0	w.	20		
m.	29.40	75	0	s.	22			11 a.m.	29.68	74	0	w.	24		
oon	29.38	74	T.	s.	22			12 noon	29.70	76	0	w.	25		

TABLE VIII

TROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VELLEY, AUGUST 19 TO 21, 1915

90th Meridian Time

	Cairo, Illinois. Latitude 37° 00′ N. Longitude 89° 10′ W. To the right of the line followed by the center of the cyclone, 60 miles.							Little Rock, Arkansas. Latitude 34° 45′ N. Longitude 92° 06′ W To the right of the line followed by th center of the cyclone, 90 miles.						
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS
						Kind	Direction							Kind
20th								20th						
1 p.m.	29.38	72	T.	s.	19	st. cu.	s.	1 p.m.	29.71	76	0	w.	21	
2 p.m.	29.38	70	T.	s.	23	Center		2 p.m.	29.72	77	0	w.	21	
3 p.m.	29.38	67	T.	s.	22	Passed		3 p.m.	29.74	79	0	w.	22	
4 p.m.	29.39	65	.02	sw.	24			4 p.m.	29.76	80	0	w.	19	
5 p.m.	29.44	64	.01	sw.	30			5 p.m.	29.77	79	0	w.	17	
6 p.m.	29.47	64	.02	sw.	30			6 p.m.	29.78	78	0	w.	16	
7 p.m.	29.51	63	T.	sw.	25	nb.	nw.	7 p.m.	29.80	76	0	w.	11	Cloudl
8 p.m.	29.55	63	T.	sw.	24			8 p.m.	29.82	73	0	sw.	7	
9 p.m.	29.60	64	T.	sw.	24			9 p.m.	29.84	72	0	w.	7	
10 p.m.	29.63	64	T.	sw.	23			10 p.m.	29.86	71	0	w.	8	
11 p.m.	29.64	63	T.	sw.	22			11 p.m.	29.87	71	0	w.	8	
12 mid.	29.65	64	0	sw.	21			12 mid.	29.88	70	0	w.	6	
21st								21st						
1 a.m.	29.66	65	0	w.	17			1 a.m.	29.89	69	0	w.	4	
2 a.m.	29.69	65	0	w.	15			2 a.m.	29.91	67	0	nw.	4	
3 a.m.	29.71	64	0	sw.	17			3 a.m.	29.91	67	0	w.	5	
4 a.m.	29.74	63	0	sw.	17			4 a.m.	29.91	66	0	w.	5	
5 a.m.	29.77	62	0	w.	14			5 a.m.	29.92	64	0	w.	5	
6 a.m.	29.80	62	0	w.	12			6 a.m.	29.93	64	0	nw.	6	
7 a.m.	29.82	62	0	sw.	7	a. st.	w.	7 a.m.	29.94	65	0	nw.	5	Cloudl
8 a.m.	29.84	66	0	w.	8			8 a.m.	29.96	66	0	nw.	7	
9 a.m.	29.87	70	0	w.	10			9 a.m.	29.98	69	0	nw.	8	
10 a.m.	29.89	72	0	w.	9			10 a.m.	30.01	71	0	nw.	8	
11 a.m.	29.89	75	0	w.	10			11 a.m.	29.99	73	0	nw.	8	
12 noon	29.89	78	0	w.	12			12 noon	29.98	74	0	nw.	7	
1 p.m.	29.89	79	0	w.	10			1 p.m.	29.98	75	0	nw.	10	
2 p.m.	29.88	80	0	w.	10			2 p.m.	29.97	77	0	nw.	10	
3 p.m.	29.88	80	0	w.	9			3 p.m.	29.96	78	0	nw.	10	
4 p.m.	29.88	80	0	w.	10			4 p.m.	29.95	79	0	nw.	9	
5 p.m.	29.88	79	0	w.	8			5 p.m.	29.94	78	0	nw.	8	
6 p.m.	29.88	77	0	w.	5			6 p.m.	29.93	77	0	nw.	6	
7 p.m.	29.88	74	0	w.	3	st. cu.	w.	7 p.m.	29.93	76	0	nw.	5	ci.
8 p.m.	29.91	72	0	w.	3			8 p.m.	29.94	74	0	nw.	1	
9 p.m.	29.93	70	0	w.	3			9 p.m.	29.94	73	0	n.	2	
10 p.m.	29.93	68	0	w.	2			10 p.m.	29.95	71	0	s.	4	
11 p.m.	29.93	67	0	w.	1			11 p.m.	29.95	70	0	s.	4	
12 mid.	29.91	67	0	w.	3			12 mid.	29.96	70	0	s.	3	

ROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

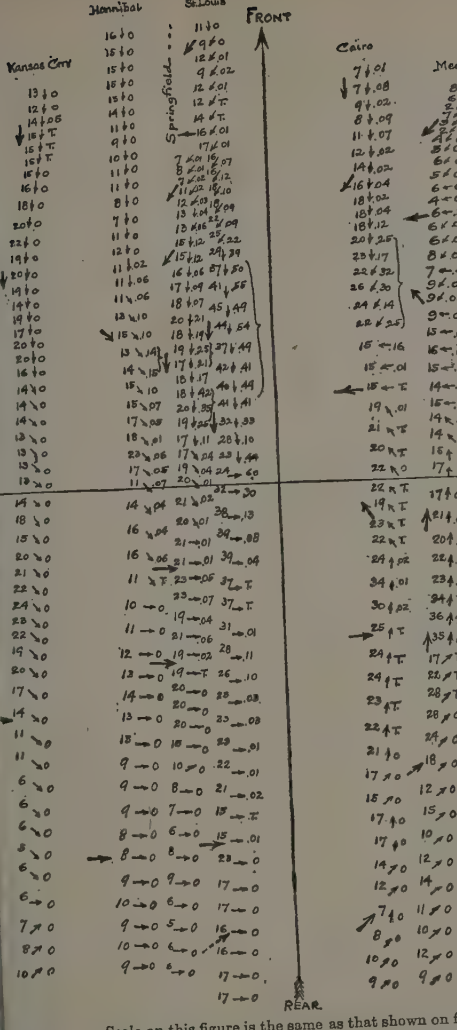
BLE VIII 90th Meridian Time

Memphis, Tennessee. Latitude 35° 09′ N. Longitude 90° 03′ W. To the right of the line followed by the center of the cyclone, 140 miles.								Nashville, Tennessee. Latitude 36° 10′ N. Longitude 86° 47′ W. To the right of the line followed by the center of the cyclone, 200 miles.							
	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
h								19th							
m.	29.98	73	.09	e.	8			1 a.m.	30.04	70	.01	ne.	6		
m.	29.98	73	.91	e.	6			2 a.m.	30.03	70	.02	ne.	7		
m.	29.95	72	1.02	e.	2			3 a.m.	30.03	70	.01	ne.	6		
m.	29.94	72	.14	e.	7			4 a.m.	30.03	70	.01	ne.	6		
m.	29.93	73	0	e.	3			5 a.m.	30.03	69	.02	ne.	7		
m.	29.93	74	0	e.	2			6 a.m.	30.03	69	.04	ne.	7		
m.	29.93	75	0	e.	4	st. cu.	e.	7 a.m.	30.03	70	.03	ne.	7	st.	ne.
m.	29.94	75	0	e.	5			8 a.m.	30.03	70	.01	ne.	6		
m.	29.94	76	0	e.	6			9 a.m.	30.04	71	.11	ne.	4		
m.	29.93	77	0	e.	5			10 a.m.	30.03	71	.25	ne.	5		
m.	29.91	79	0	se.	6			11 a.m.	30.02	72	T.	ne.	9		
oon	29.86	82	0	se.	4			12 noon	30.01	73	.14	ne.	7		
m.	29.84	77	.28	se.	6	nb.	se.	1 p.m.	30.00	73	.18	se.	3	st. cu.	?
m.	29.81	77	.02	e.	6			2 p.m.	29.98	73	T.	ne.	5		
m.	29.79	77	.04	e.	6			3 p.m.	29.98	75	0	ne.	5		
m.	29.77	77	.07	e.	8			4 p.m.	29.98	74	0	ne.	9		
m.	29.76	76	.58	se.	7			5 p.m.	29.97	74	0	ne.	10		
m.	29.73	76	.01	e.	9			6 p.m.	29.96	73	T.	ne.	9	a. st.	s.
m.	29.71	76	.03	e.	9	nb.	s.	7 p.m.	29.95	73	T.	e.	12	st.	e.
m.	29.70	75	.03	se.	9			8 p.m.	29.95	72	T.	e.	11		
m.	29.68	75	.02	se.	15			9 p.m.	29.94	72	0	e.	12		
m.	29.66	75	.06	se.	16			10 p.m.	29.94	71	T.	e.	8		
m.	29.62	74	.13	se.	15			11 p.m.	29.92	71	0	e.	9		
id.	29.61	74	.59	se.	14			12 mid.	29.91	71	0	e.	10		
h								20th							
m.	29.57	74	.20	se.	15			1 a.m.	29.86	71	.01	e.	10		
m.	29.55	75	.09	s.	14			2 a.m.	29.85	71	T.	e.	11		
m.	29.53	75	0	s.	14			3 a.m.	29.80	70	.03	e.	15		
m.	29.52	74	0	sw.	15	Center		4 a.m.	29.78	71	.04	se.	16		
m.	29.52	73	0	sw.	17	Passed		5 a.m.	29.72	71	.06	se.	23		
m.	29.53	73	0	sw.	17			6 a.m.	29.69	71	.05	se.	29		
n.	29.56	71	.01	sw.	21	st.	sw.	7 a.m.	29.65	71	.01	se.	30	st.	se.
n.	29.56	71	.01	sw.	20			8 a.m.	29.64	70	.07	se.	33		
n.	29.57	69	.01	sw.	22			9 a.m.	29.65	75	.01	se.	25		
n.	29.58	69	.02	sw.	23			10 a.m.	29.63	76	0	se.	26		
n.	29.60	69	T.	sw.	34			11 a.m.	29.62	74	.34	s.	26		
oon	29.62	70	T.	sw.	36			12 noon	29.60	73	.01	s.	27		

TROPICAL CYCLONE WHILE PASSING OVER THE CENTRAL MISSISSIPPI VALLEY, AUGUST 19 TO 21, 1915

TABLE VIII 90th Meridian Time

Memphis, Tennessee. Latitude 35° 09′ N. Longitude 90° 03′ W. To the right of the line followed by the center of the cyclone, 140 miles.								Nashville, Tennessee. Latitude 36° 10′ N. Longitude 86° 47′ W. To the right of the line followed by the center of the cyclone, 200 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
20th								20th							
1 p.m.	29.63	73	0	w.	35	st. cu.	sw.	1 p.m.	29.60	78	.09	s.	29	st. cu.	s.
2 p.m.	29.64	70	T.	w.	17			2 p.m.	29.59	78	T.	s.	26	Center	
3 p.m.	29.65	75	T.	w.	22			3 p.m.	29.60	76	0	sw.	33	Passed	
4 p.m.	29.67	75	T.	sw.	28			4 p.m.	29.62	73	0	sw.	30		
5 p.m.	29.72	76	0	w.	28			5 p.m.	29.61	74	T.	s.	24		
6 p.m.	29.73	76	0	w.	24			6 p.m.	29.62	70	.09	sw.	30		
7 p.m.	29.77	75	0	w.	18	st. cu.	w.	7 p.m.	29.63	69	T.	sw.	16	st. cu.	sw.
8 p.m.	29.79	74	0	w.	12			8 p.m.	29.66	68	.01	sw.	24		
9 p.m.	29.80	74	0	w.	15			9 p.m.	29.68	68	.01	sw.	23		
10 p.m.	29.82	71	0	w.	10			10 p.m.	29.69	65	0	sw.	26		
11 p.m.	29.84	70	0	w.	12			11 p.m.	29.69	65	.01	sw.	21		
12 mid.	29.85	68	0	w.	14			12 mid.	29.69	66	0	sw.	21		
21st								21st							
1 a.m.	29.87	67	0	w.	11			1 a.m.	29.71	67	0	sw.	18		
2 a.m.	29.88	66	0	w.	10			2 a.m.	29.72	66	0	sw.	18		
3 a.m.	29.89	66	0	w.	12			3 a.m.	29.73	66	0	sw.	21		
4 a.m.	29.89	65	0	w.	19			4 a.m.	29.74	66	0	sw.	21		
5 a.m.	29.89	64	0	w.	6			5 a.m.	29.77	64	0	sw.	22		
6 a.m.	29.90	64	0	nw.	9			6 a.m.	29.80	65	0	sw.	20		
7 a.m.	29.94	64	0	w.	9	Cloudless		7 a.m.	29.83	66	0	sw.	22	st. cu.	w.
8 a.m.	29.99	65	0	w.	10			8 a.m.	29.84	67	0	sw.	24		
9 a.m.	30.08	67	0	nw.	10			9 a.m.	29.86	69	0	w.	20		
10 a.m.	30.08	69	0	nw.	9			10 a.m.	29.88	74	0	w.	21		
11 a.m.	30.08	72	0	nw.	6			11 a.m.	29.89	76	0	w.	19		
12 noon	30.07	75	0	nw.	6			12 noon	29.89	81	0	w.	18		
1 p.m.	30.05	76	0	nw.	8			1 p.m.	29.88	83	0	w.	16	ci. st. cu.	0 w.
2 p.m.	30.04	78	0	nw.	8			2 p.m.	29.87	84	0	sw.	17		
3 p.m.	30.03	79	0	sw.	8			3 p.m.	29.87	83	0	sw.	19		
4 p.m.	30.03	80	0	w.	7			4 p.m.	29.88	83	0	w.	21		
5 p.m.	30.03	80	0	w.	7			5 p.m.	29.88	82	0	w.	19		
6 p.m.	30.03	79	0	w.	7			6 p.m.	29.89	79	0	w.	15		
7 p.m.	30.03	76	0	w.	7	ci. st.	sw.	7 p.m.	29.90	76	0	w.	10	st. cu.	w.
8 p.m.	30.03	74	0	w.	5			8 p.m.	29.92	73	0	w.	11		
9 p.m.	30.04	73	0	w.	2			9 p.m.	29.92	72	0	w.	9		
10 p.m.	30.05	72	0	w.	2			10 p.m.	29.92	70	0	w.	9		
11 p.m.	30.05	71	0	w.	2			11 p.m.	29.93	68	0	w.	5		
12 mid.	30.05	70	0	w.	2			12 mid.	29.94	68	0	w.	7		



Scale on this figure is the same as that shown on figure 18.

ire 15. Records made during the passage, over the central Mississippi Valley, of the
al cyclone, August 19-21, 1915. Intersection of cross lines represents the center of the
e. Points of small regular arrows rest on positions of stations at the time the records
nade; figures on the left of the arrows are wind velocities in miles per hour; figures on
ght of the arrows are the hourly precipitation measured to hundredths of an inch.
ts show the greatest hourly precipitation intensity.
vy arrows represent the direction of the lower clouds.
ten arrows represent the directions of the upper clouds, the cirrus types.
cyclone falls in the group of the larger traveling cyclones.

IX

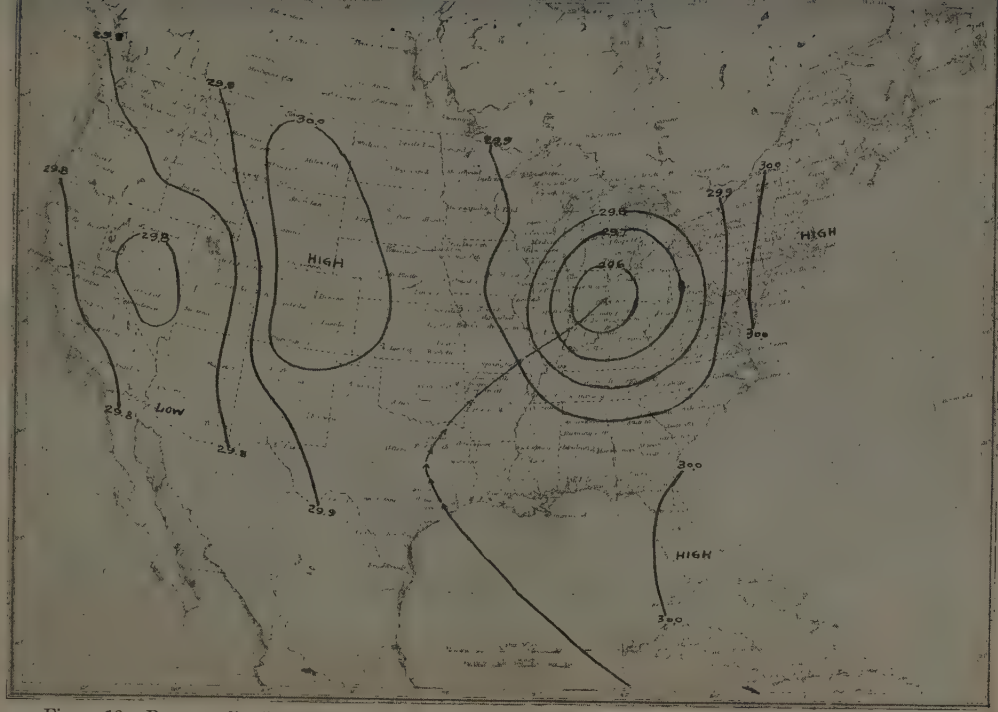
Tropical Cyclone While Passing Over the Great Lak August 20-22, 1915

The meteorological data recorded during the passage of t cyclone over the Great Lakes are given in Table IX. We n have the cyclone after it had been inland six days and travel something like 1800 miles, which makes these data of exceptio value. The winds and precipitation as related to the cyclo center and the direction of movement are charted in Figure The winds in the right rear quadrant were in the same gene direction as that in which the cyclone was traveling. In t right front quadrant the winds came up around the center a across the line of advance with very little incurvature, they th moved back through the left front quadrant, almost direc opposed to the line of advance of the cyclone, into the left r quadrant where they shifted and took up a direction across t line of advance. The lower clouds did not differ greatly direction from the surface winds. The upper clouds were fr the west and southwest mainly across the line of advance, a in the prevailing direction of these clouds for the region involv

Owing to the uneven topography of this region part of t precipitation was unquestionably orographic and it is not pos ble to separate this from the cyclonic rainfall. At Toledo, Oh on the line followed by the center of the cyclone, .38 of an in occurred in the front and .04 in the rear of the center; at Cle land, Ohio, 40 miles to the right of the center, .54 fell before t passage and .11 after the center passed. At Lansing, Mich., 1 miles to the left of the center, where the topography is rollin the precipitation was .63 in the front and .50 in the rear of t cyclone.

Changes in Pressure During the Life of This Cyclone

As the cyclone of August 16 to 22, 1915, moved inland bef it commenced curving, the isobars outside of the circular isob were crowded together in the right half and spread out causi a bulge in the left half of the cyclonic area. During the peri when the cyclone was curving, the isobars were crowded togeth


29.8
29.8
30.0
29.8
29.8
HIGH
29.8
LOW
29.8
29.9
29.9
29.7
29.6
30.0
29.9
HIGH
30.0
30.0
HIGH
30.0

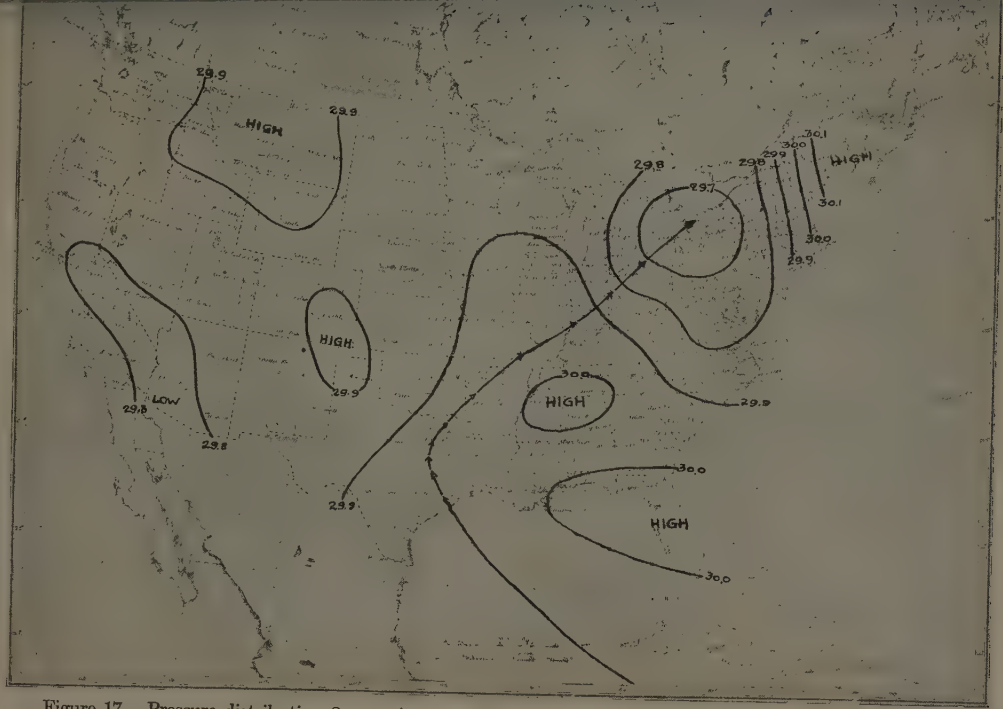


Figure 17. Pressure distribution 8 a.m. August 29, 1915, 75th Meridian Time

n the front of the cyclone and spread out causing a bulge in he left rear quadrant and the rear of the cyclone. After the urve the isobars were crowded together in the left front quad- ant and bulged out in the right rear quadrant. This crowding f the isobars in certain parts and spreading out causing a bulge n other parts unmistakably reflects the action of the air current n which the cyclone was traveling and which determined the lirection towards which the cyclonic center advanced.

Precipitation During Passage of the Cyclone from the Gulf to the Lakes

Notwithstanding the left half of the cyclone of August 17-22, 915, moved directly over the Great Lakes, there was no increase n precipitation in the left half of the cyclonic area as the yclone approached and moved over this body of water. On the ontrary, while the cyclone was approaching and crossing the akes the precipitation decreased in the left half in propor- ion to the decrease in the right half of the cyclonic area. his cyclone furnishes a good example for the study of the in- uences of topography and the position of the water areas on ne precipitation in cyclones.

The distribution of the total precipitation during the passage f this cyclone as related to the path along which the cyclonic enter advanced is of special interest and is shown on Figure 19. Ve have on this chart the precipitation as it occurred along ne path of the cyclone during a period of six days and over a istance of nearly 2000 miles.

There were no anticyclonic or other conditions to influence ne rainfall during the passage of this cyclone from the Gulf to ne Lakes, hence topography is the only outside factor to be onsidered. The precipitation did not extend to any great dis- nce to the left of the line followed by the center of the cyclone hile on the right of that line we find precipitation occurring ith the passage of the cyclone all the way to the Atlantic oast, the greatest distance to the right being 1200 miles. The mount of rainfall diminished rapidly to the left of the center. he greatest rainfall is to the right of the line followed by the nter. The rainfall along the right side of the path showed ry little decrease in amounts from the time the cyclone moved

inland until it reached the mountainous region of weste
Arkansas, where the rainfall intensity diminished and was on
about half the amount previously recorded. When the cyclo
reached the level lands of the central Mississippi Valley, t
rainfall intensity showed a marked increase, the amounts reac
ing 8 to 10 inches in northeast Arkansas and southeast Missou
being nearly as heavy as when the cyclone moved in on t
Texas Coast.

The heavy rainfall over northeastern Arkansas, southeaste
Missouri, and south-central Illinois was accompanied by a d
cided increase in the intensity of the cyclone. This heavy pr
cipitation was from water vapor supplied by the winds whi
had moved from the Gulf of Mexico up the Mississippi Valle
without encountering sufficient elevations to cool the air a
cause the precipitation of any material part of the moistu
before reaching the right front quadrant of the cyclone.

The front of the cyclone, after it had crossed the centr
Mississippi Valley and continued northeastward, had the App
lachian Plateau and its mountains between the cyclone and t
sources of water supply, the Gulf of Mexico and the Atlant
Ocean, and the rainfall in the cyclone diminished rapidly
intensity as appears in Figure 19. Heavy precipitation occurre
along the Appalachian Plateau as the cyclone advanced nort
eastward from the Mississippi Valley; the air which was movi
from the Gulf of Mexico and the Atlantic Ocean towards t
cyclonic center was cooled in ascent while passing over t
Appalachian Mountains and a large portion of the moistu
which it carried was precipitated on the windward side of the
mountains. When the air finally reached the cyclone it ha
thus been deprived of a large percentage of its aqueous vap
and the precipitation in the cyclonic area diminished as a natur
consequence. The curtailment of the moisture supply of t
cyclonic area was attended by a rapid and marked decrease
the intensity of the cyclone.

TROPICAL CYCLONE WHILE PASSING OVER THE GREAT LAKES, AUGUST 20 TO 22, 1915
TABLE IX

Grand Haven, Michigan. Latitude 43° 05′ N. Longitude 86° 13′ W. To the left of the line followed by the center of the cyclone, 200 miles. 90th Meridian Time								Lansing, Michigan. Latitude 42° 44′ N. Longitude 84° 26′ W. To the left of the line followed by the center of the cyclone, 130 miles. 90th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction
20th								20th							
1 a.m.	30.01	57	0	n.	6			1 a.m.	30.02	52	0	e.	2		
2 a.m.	30.01	56	0	n.	6			2 a.m.	30.02	51	0	e.	2		
3 a.m.	30.01	54	0	n.	5			3 a.m.	30.02	49	0	0	0		
4 a.m.	29.99	52	0	e.	4			4 a.m.	30.00	49	0	s.	1		
5 a.m.	30.00	52	0	e.	4			5 a.m.	30.00	47	0	n.	1		
6 a.m.	30.00	53	0	e.	4			6 a.m.	30.01	49	0	ne.	2		
7 a.m.	29.98	56	0	e.	3	a. st.	w.	7 a.m.	30.01	56	0	ne.	2	st.	nw.
8 a.m.	29.98	60	0	e.	4			8 a.m.	30.00	60	0	ne.	1		
9 a.m.	29.97	64	0	e.	7			9 a.m.	29.99	65	0	ne.	3		
10 a.m.	29.95	69	0	e.	8			10 a.m.	29.98	70	0	e.	5		
11 a.m.	29.93	72	0	e.	10			11 a.m.	29.96	70	0	e.	7		
12 noon	29.92	73	0	e.	11	a. st.	w.	12 noon	29.94	72	0	e.	8		
1 p.m.	29.90	73	0	e.	12			1 p.m.	29.91	72	0	e.	8		
2 p.m.	29.88	74	0	e.	11			2 p.m.	29.88	73	0	e.	7		
3 p.m.	29.86	73	0	e.	11			3 p.m.	29.86	71	0	ne.	6		
4 p.m.	29.84	72	0	e.	11			4 p.m.	29.85	69	0	e.	5		
5 p.m.	29.83	70	0	ne.	9			5 p.m.	29.83	68	0	ne.	4		
6 p.m.	29.82	68	0	ne.	7			6 p.m.	29.81	66	0	ne.	4		
7 p.m.	29.81	66	0	ne.	6	a. st.	w.	7 p.m.	29.80	65	0	ne.	4	st.	ne.
8 p.m.	29.81	65	0	ne.	8			8 p.m.	29.80	65	0	ne.	5		
9 p.m.	29.80	65	0	ne.	11			9 p.m.	29.78	65	0	ne.	6		
10 p.m.	29.79	65	0	ne.	10			10 p.m.	29.75	64	0	ne.	6		
11 p.m.	29.78	64	0	ne.	10			11 p.m.	29.73	63	0	ne.	6		
12 mid.	29.76	64	0	ne.	11			12 mid.	29.73	62	0	ne.	7		
21st								21st							
1 a.m.	29.73	64	0	ne.	15			1 a.m.	29.72	60	.04	ne.	5		
2 a.m.	29.72	64	0	ne.	15			2 a.m.	29.69	60	.06	ne.	6		
3 a.m.	29.71	64	T.	ne.	13			3 a.m.	29.66	61	.08	ne.	6		
4 a.m.	29.69	62	.03	ne.	15			4 a.m.	29.66	61	.13	ne.	6		
5 a.m.	29.68	61	.01	ne.	15			5 a.m.	29.65	62	.05	ne.	7		
6 a.m.	29.68	60	.01	ne.	13			6 a.m.	29.62	62	.01	ne.	9		
7 a.m.	29.68	61	T.	ne.	16	st.	ne.	7 a.m.	29.61	63	.02	ne.	9	nb.	ne.
8 a.m.	29.67	62	T.	ne.	18			8 a.m.	29.60	64	.23	ne.	8		
9 a.m.	29.68	63	T.	ne.	18	Center		9 a.m.	29.58	64	.01	ne.	9	Center	
10 a.m.	29.68	66	T.	n.	20	Passed		10 a.m.	29.58	65	.03	ne.	8	Passed	
11 a.m.	29.69	66	.01	n.	17			11 a.m.	29.59	65	.08	ne.	6		
12 noon	29.69	70	T.	ne.	20	st. cu.	ne.	12 noon	29.61	65	.07	ne.	6		

TROPICAL CYCLONE WHILE PASSING OVER THE GREAT LAKES, AUGUST 20 TO 22, 19

TABLE IX

Grand Haven, Michigan. Latitude 43° 05′ N. Longitude 86° 13′ W. To the left of the line followed by the center of the cyclone, 200 miles. 90th Meridian Time								Lansing, Michigan. Latitude 42° 44′ N. Longitude 84° 26′ To the left of the line followed by t center of the cyclone, 130 miles. 90th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUD	
						Kind	Direction							Kind	
21st								21st							
1 p.m.	29.69	73	0	ne.	18			1 p.m.	29.61	65	.01	ne.	7		
2 p.m.	29.69	74	0	n.	14			2 p.m.	29.61	65	.07	ne.	7		
3 p.m.	29.69	75	0	n.	11			3 p.m.	29.62	64	.03	ne.	7		
4 p.m.	29.70	74	0	ne.	9			4 p.m.	29.63	64	.05	ne.	7		
5 p.m.	29.72	73	0	n.	8			5 p.m.	29.63	64	.04	ne.	7		
6 p.m.	29.73	72	0	n.	8			6 p.m.	29.63	63	.10	ne.	7		
7 p.m.	29.73	71	0	n.	8	a. st.	w.	7 p.m.	29.63	63	.03	ne.	8	st.	
8 p.m.	29.75	69	0	n.	10	st. cu.	n.	8 p.m.	29.65	63	T.	n.	9		
9 p.m.	29.77	68	0	n.	9			9 p.m.	29.65	63	.01	n.	7		
10 p.m.	29.79	66	0	n.	8			10 p.m.	29.65	62	.01	n.	6		
11 p.m.	29.79	65	0	n.	8			11 p.m.	29.66	63	0	n.	8		
12 mid.	29.79	64	0	n.	9			12 mid.	29.67	63	0	n.	6		
22d								22d							
1 a.m.	29.79	64	0	n.	10			1 a.m.	29.67	63	0	n.	6		
2 a.m.	29.79	63	0	nw.	11			2 a.m.	29.70	63	0	nw.	9		
3 a.m.	29.79	63	0	nw.	10			3 a.m.	29.70	61	0	nw.	7		
4 a.m.	29.80	63	0	nw.	10			4 a.m.	29.72	61	0	nw.	5		
5 a.m.	29.82	61	0	nw.	9			5 a.m.	29.72	61	0	nw.	5		
6 a.m.	29.83	62	0	nw.	10			6 a.m.	29.74	62	0	nw.	5		
7 a.m.	29.83	65	0	nw.	9	Cloudless		7 a.m.	29.77	62	0	nw.	6	st.	
8 a.m.	29.83	67	0	nw.	10			8 a.m.	29.78	64	0	nw.	5		
9 a.m.	29.83	68	0	nw.	13			9 a.m.	29.79	68	0	nw.	6		
10 a.m.	29.84	69	0	nw.	13			10 a.m.	29.80	73	0	nw.	8		
11 a.m.	29.84	70	0	nw.	12			11 a.m.	29.80	74	0	nw.	8		
12 noon	29.84	71	0	w.	12			12 noon	29.81	76	0	nw.	7		
1 p.m.	29.85	71	0	w.	14			1 p.m.	29.81	76	0	nw.	7		
2 p.m.	29.84	72	0	w.	13			2 p.m.	29.80	77	0	nw.	7		
3 p.m.	29.83	73	0	w.	10			3 p.m.	29.80	78	0	nw.	7		
4 p.m.	29.83	71	0	w.	8			4 p.m.	29.79	78	0	nw.	7		
5 p.m.	29.82	71	0	sw.	5			5 p.m.	29.79	76	0	w.	5		
6 p.m.	29.82	69	0	sw.	6			6 p.m.	29.79	73	0	w.	4		
7 p.m.	29.82	66	0	sw.	4	a. cu.	sw.	7 p.m.	29.81	67	0	w.	3	ci.	
8 p.m.	29.82	65	0	s.	5			8 p.m.	29.81	63	0	w.	2		
9 p.m.	29.82	64	0	s.	4			9 p.m.	29.82	65	0	sw.	4		
10 p.m.	29.82	62	0	se.	5			10 p.m.	29.82	58	0	sw.	3		
11 p.m.	29.82	61	0	se.	5			11 p.m.	29.83	56	0	sw.	3		
12 mid.	29.82	60	0	se.	5			12 mid.	29.83	55	0	sw.	3		

Toledo, Ohio.

Latitude 41° 40′ N. Longitude 83° 34′ W. Very nearly on the line followed by the center of the cyclone.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
20th							
1 a.m.	30.04	64	0	se.	3		
2 a.m.	30.03	62	0	se.	4		
3 a.m.	30.03	61	0	n.	5		
4 a.m.	30.02	62	0	n.	4		
5 a.m.	30.02	60	0	n.	4		
6 a.m.	30.02	61	0	n.	4		
7 a.m.	30.01	63	0	ne.	6	ci. st.	w.
8 a.m.	30.00	65	0	e.	7		
9 a.m.	30.00	67	0	e.	9		
10 a.m.	29.98	68	0	ne.	14		
11 a.m.	29.97	69	0	e.	14		
12 noon	29.93	70	0	e.	17		
1 p.m.	29.91	70	0	e.	19		
2 p.m.	29.89	70	0	ne.	17		
3 p.m.	29.85	69	0	ne.	18		
4 p.m.	29.83	69	0	ne.	17		
5 p.m.	29.80	69	0	e.	17		
6 p.m.	29.79	68	T.	e.	16		
7 p.m.	29.79	67	.02	e.	15	nb.	e.

Cleveland, Ohio

Latitude 41° 30′ N. Longitude 81° 42′ W. To the right of the line followed by the center of the cyclone, 40 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
20th							
1 a.m.	30.06	48	0	e.	11		
2 a.m.	30.05	47	0	e.	10		
3 a.m.	30.05	48	0	e.	8		
4 a.m.	30.04	48	0	e.	7		
5 a.m.	30.04	50	0	e.	7		
6 a.m.	30.03	51	0	e.	10		
7 a.m.	30.01	51	0	se.	10		
8 a.m.	30.01	51	0	se.	7	st.	e.
9 a.m.	30.01	54	0	se.	8		
10 a.m.	29.99	57	0	se.	12		
11 a.m.	29.98	58	0	se.	12		
12 noon	29.94	57	0	se.	13		
1 p.m.	29.91	58	0	se.	16		
2 p.m.	29.88	57	0	se.	16		
3 p.m.	29.88	57	0	se.	21		
4 p.m.	29.84	57	0	se.	17		
5 p.m.	29.85	57	0	se.	19		
6 p.m.	29.84	58	0	se.	17		
7 p.m.	29.83	58	T.	se.	14		

Pittsburg, Pennsylvania.

Latitude 40° 32′ N. Longitude 80° 02′ W. To the right of the line followed by the center of the cyclone, 110 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
20th							
1 a.m.	30.03	62	0	ne.	3		
2 a.m.	30.01	61	0	ne.	4		
3 a.m.	30.01	60	0	ne.	5		
4 a.m.	30.01	59	0	ne.	6		
5 a.m.	30.02	58	0	ne.	6		
6 a.m.	30.02	58	0	ne.	5		
7 a.m.	30.01	59	0	e.	5		
8 a.m.	30.01	62	0	e.	4		
9 a.m.	29.99	70	0	e.	6		
10 a.m.	29.97	73	0	se.	13		
11 a.m.	29.95	74	0	se.	12		
12 noon	29.94	76	0	se.	13		
1 p.m.	29.93	77	0	se.	13	a. st.	sw
2 p.m.	29.92	78	0	se.	13		
3 p.m.	29.91	78	T.	se.	12		
4 p.m.	29.90	77	T.	se.	14		
5 p.m.	29.89	75	0	se.	19		
6 p.m.	29.89	73	T.	se.	16		
7 p.m.	29.88	72	T.	se.	13		

TABLE IX

Toledo, Ohio.
Latitude 41° 40′ N. Longitude 83° 34′ W.
Very nearly on the line followed by the center of the cyclone.
90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
20th							
8 p.m.	29.78	66	T.	e.	12		
9 p.m.	29.76	66	T.	e.	13		
10 p.m.	29.75	65	.06	e.	13		
11 p.m.	29.74	63	.10	e.	17		
12 mid.	29.71	63	.04	e.	22		
21st							
1 a.m.	29.68	64	0	e.	23		
2 a.m.	29.64	65	0	e.	17		
3 a.m.	29.63	65	T.	e.	15		
4 a.m.	29.62	65	.01	e.	16		
5 a.m.	29.60	65	0	e.	15		
6 a.m.	29.59	65	.02	se.	15	ci.	w.
7 a.m.	29.59	66	0	se.	13	a. st.	w.
8 a.m.	29.59	67	0	se.	19	st.	se.
9 a.m.	29.59	63	.02	s.	13		
10 a.m.	29.60	64	T.	s.	9		
11 a.m.	29.61	64	.01	se.	10	nb	s

Cleveland, Ohio.
Latitude 41° 30′ N. Longitude 81° 42′ W.
To the right of the line followed by the center of the cyclone, 40 miles.
75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
20th							
8 p.m.	29.82	58	.01	se.	18	st.	se.
9 p.m.	29.80	60	.06	se.	15		
10 p.m.	29.79	61	.01	se.	15		
11 p.m.	29.79	61	.01	se.	13		
12 mid.	29.78	61	.01	se.	11		
21st							
1 a.m.	29.75	61	.40	se.	12		
2 a.m.	29.72	60	T.	se.	12		
3 a.m.	29.70	61	.01	se.	12		
4 a.m.	29.67	61	0	se.	13		
5 a.m.	29.65	61	0	se.	14		
6 a.m.	29.65	62	0	se.	14		
7 a.m.	29.65	63	0	se.	14	a. cu.	sw.
8 a.m.	29.64	65	T.	se.	16	st.	se.
9 a.m.	29.63	70	.02	s.	23		
10 a.m.	29.65	72	.01	s.	27		
11 a.m.	29.65	75	T.	s.	24		

Pittsburg, Pennsylvania.
Latitude 40° 32′ N. Longitude 80° 02′ W.
To the right of the line followed by the center of the cyclone, 110 miles.
75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
20th							
8 p.m.	29.85	71	T.	se.	12	st. cu.	se.
9 p.m.	29.84	69	.01	se.	14		
10 p.m.	29.85	69	0	se.	14		
11 p.m.	29.85	67	.02	se.	17		
12 mid.	29.82	66	.04	se.	15		
21st							
1 a.m.	29.83	66	T.	e.	15		
2 a.m.	29.78	67	0	se.	12		
3 a.m.	29.74	68	.01	se.	12		
4 a.m.	29.73	68	.12	se.	16		
5 a.m.	29.73	69	0	se.	17		
6 a.m.	29.73	69	0	se.	19		
7 a.m.	29.71	70	0	se.	20		
8 a.m.	29.70	71	0	se.	23	st. cu.	se.
9 a.m.	29.67	75	0	se.	21		
10 a.m.	29.67	80	0	se.	19		
11 a.m.	29.66	80	0	s.	17		

Toledo, Ohio.

Latitude 41° 40′ N. Longitude 83° 34′ W. Very nearly on the line followed by the center of the cyclone.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
21st							
1 p.m.	29.60	63	.06	se.	7		
2 p.m.	29.60	63	.01	se.	6		
3 p.m.	29.59	62	.01	se.	6	Center	
4 p.m.	29.60	63	.01	se.	4	Passed	
5 p.m.	29.60	64	.03	n.	3		
6 p.m.	29.60	64	.01	nw.	3		
7 p.m.	29.61	64	0	nw.	6	st.	n.
8 p.m.	29.61	64	0	nw.	10		
9 p.m.	29.63	64	0	nw.	10		
10 p.m.	29.64	64	0	nw.	9		
11 p.m.	29.65	64	0	nw.	9		
12 mid.	29.66	64	0	nw.	8		
22d							
1 a.m.	29.66	64	0	w.	7		
2 a.m.	29.66	65	0	w.	9		
3 a.m.	29.66	65	0	w.	9		
4 a.m.	29.67	65	0	w.	9		
5 a.m.	29.68	65	T.	w.	10		
6 a.m.	29.70	65	T.	w.	10		

Cleveland, Ohio

Latitude 41° 30′ N. Longitude 81° 42′ W. To the right of the line followed by the center of the cyclone, 40 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
21st							
1 p.m.	29.64	64	T.	sw.	26	st. cu.	sw.
2 p.m.	29.64	70	T.	sw.	21	Center	
3 p.m.	29.64	78	T.	sw.	22	Passed	
4 p.m.	29.64	78	T.	sw.	23		
5 p.m.	29.64	79	.01	sw.	23		
6 p.m.	29.65	78	.04	sw.	17		
7 p.m.	29.65	77	T.	sw.	16		
8 p.m.	29.64	76	T.	sw.	14	cu.	sw.
9 p.m.	29.63	73	T.	sw.	12		
10 p.m.	29.64	70	0	sw.	13		
11 p.m.	29.65	68	0	sw.	12		
12 mid.	29.66	67	0	sw.	10		
22d							
1 a.m.	29.67	64	0	sw.	13		
2 a.m.	29.67	62	0	w.	14		
3 a.m.	29.67	61	0	w.	10		
4 a.m.	29.67	60	T.	sw.	9		
5 a.m.	29.67	58	T.	w.	12		
6 a.m.	29.68	58	T.	w.	9		

Pittsburg, Pennsylvania.

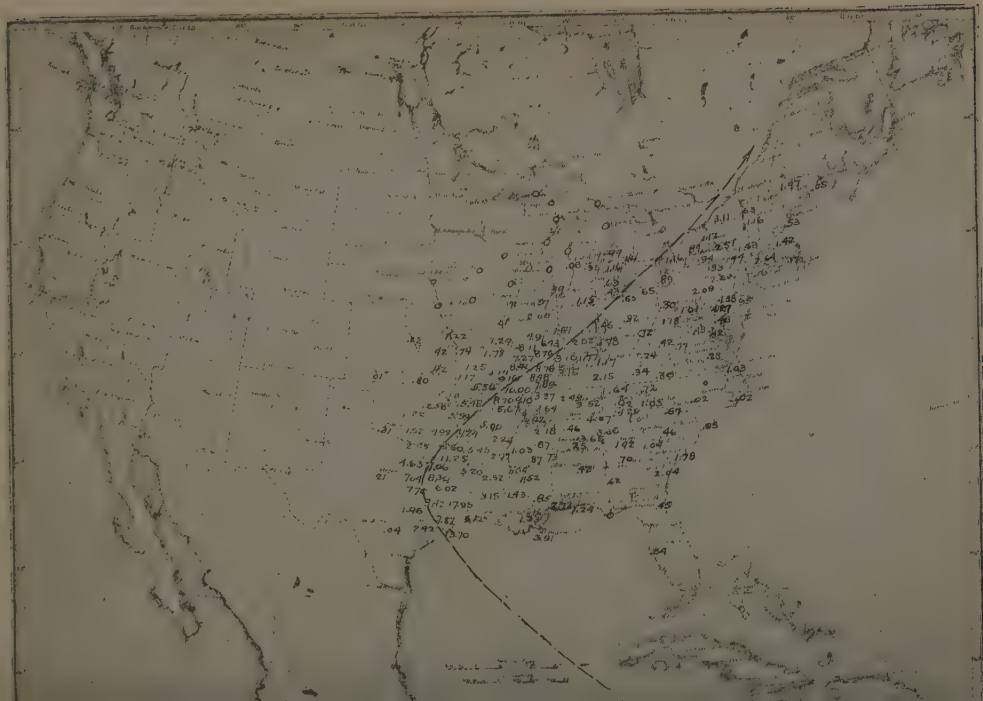
Latitude 40° 32′ N. Longitude 80° 02′ W. To the right of the line followed by the center of the cyclone, 110 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
21st							
1 p.m.	29.65	77	0	sw.	18	Center	
2 p.m.	29.65	73	0	w.	23	Passed	
3 p.m.	29.66	76	0	w.	19		
4 p.m.	29.67	68	T.	sw.	20		
5 p.m.	29.68	69	0	sw.	16		
6 p.m.	29.69	67	T.	sw.	15		
7 p.m.	29.69	66	.01	sw.	12		
8 p.m.	29.70	65	T.	sw.	15	st. cu.	sw.
9 p.m.	29.70	63	T.	sw.	14		
10 p.m.	29.70	63	T.	sw.	13		
11 p.m.	29.70	63	T.	s.	11		
12 mid.	29.70	63	T.	sw.	14		
22d							
1 a.m.	29.69	63	.05	s.	9		
2 a.m.	29.68	63	.02	s.	10		
3 a.m.	29.68	63	.01	sw.	16		
4 a.m.	29.69	63	T.	sw.	15		
5 a.m.	29.69	62	.01	sw.	12		
6 a.m.	29.70	63	0	sw.	9		

TABLE IX

Toledo, Ohio. Latitude 41° 40′ N. Longitude 83° 34′ W. Very nearly on the line followed by the center of the cyclone. 90th Meridian Time									Cleveland, Ohio Latitude 41° 30′ N. Longitude 81° 42′ W. To the right of the line followed by the center of the cyclone, 40 miles. 75th Meridian Time									Pittsburg, Pennsylvania. Latitude 40° 32′ N. Longitude 80° 02′ W. To the right of the line followed by the center of the cyclone, 110 miles. 75th Meridian Time								
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS			Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS			Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		
						Kind	Direction								Kind	Direction								Kind	Direction	
22d									22d									22d								
7 a.m.	29.72	65	T.	nw.	13	st.		nw.	7 a.m.	29.70	58	0	sw.	7				7 a.m.	29.72	63	T.	sw.	10			
8 a.m.	29.75	65	0	nw.	14				8 a.m.	29.71	58	0	sw.	7	st.		sw.	8 a.m.	29.73	64	T.	sw.	12	st. cu.		sw.
9 a.m.	29.76	65	0	nw.	16				9 a.m.	29.72	58	T.	sw.	8				9 a.m.	29.75	65	T.	w.	12			
10 a.m.	29.78	67	0	nw.	12				10 a.m.	29.74	59	T.	w.	8				10 a.m.	29.79	66	0	w.	14			
11 a.m.	29.80	68	0	nw.	14				11 a.m.	29.77	57	.01	w.	10				11 a.m.	29.79	67	T.	w.	16			
12 noon	29.80	70	0	nw.	12				12 noon	29.78	56	.03	w.	10				12 noon	29.79	66	0	w.	15			
1 p.m.	29.80	73	0	nw.	9				1 p.m.	29.78	61	.01	w.	7				1 p.m.	29.81	68	0	w.	15			
2 p.m.	29.80	77	0	nw.	11				2 p.m.	29.79	58	T.	nw.	7				2 p.m.	29.81	66	T.	w.	13			
3 p.m.	29.81	78	0	nw.	13				3 p.m.	29.79	60	T.	nw.	9				3 p.m.	29.81	66	T.	sw.	15			
4 p.m.	29.82	78	0	w.	16				4 p.m.	29.80	62	T.	nw.	10				4 p.m.	29.81	66	T.	sw.	12			
5 p.m.	29.82	77	0	w.	12				5 p.m.	29.80	61	T.	nw.	11				5 p.m.	29.83	64	T.	sw.	12			
6 p.m.	29.82	76	0	w.	10				6 p.m.	29.82	62	.01	nw.	6				6 p.m.	29.84	65	T.	sw.	15			
7 p.m.	29.83	73	0	w.	12	ci.		w.	7 p.m.	29.84	60	T.	w.	9				7 p.m.	29.86	65	T.	w.	14			
8 p.m.	29.84	71	0	w.	14				8 p.m.	29.84	57	T.	w.	15	ci. cu.		sw.	8 p.m.	29.86	65	T.	w.	13	st. cu.		w.
9 p.m.	29.85	70	0	w.	16				9 p.m.	29.84	54	0	nw.	17				9 p.m.	29.87	65	0	w.	12			
10 p.m.	29.86	69	0	w.	16				10 p.m.	29.84	53	0	nw.	16				10 p.m.	29.89	66	0	w.	12			
11 p.m.	29.87	67	0	w.	14				11 p.m.	29.85	53	0	nw.	13				11 p.m.	29.90	65	0	w.	8			
																		12 mid.	29.90	65	0	sw.	6			



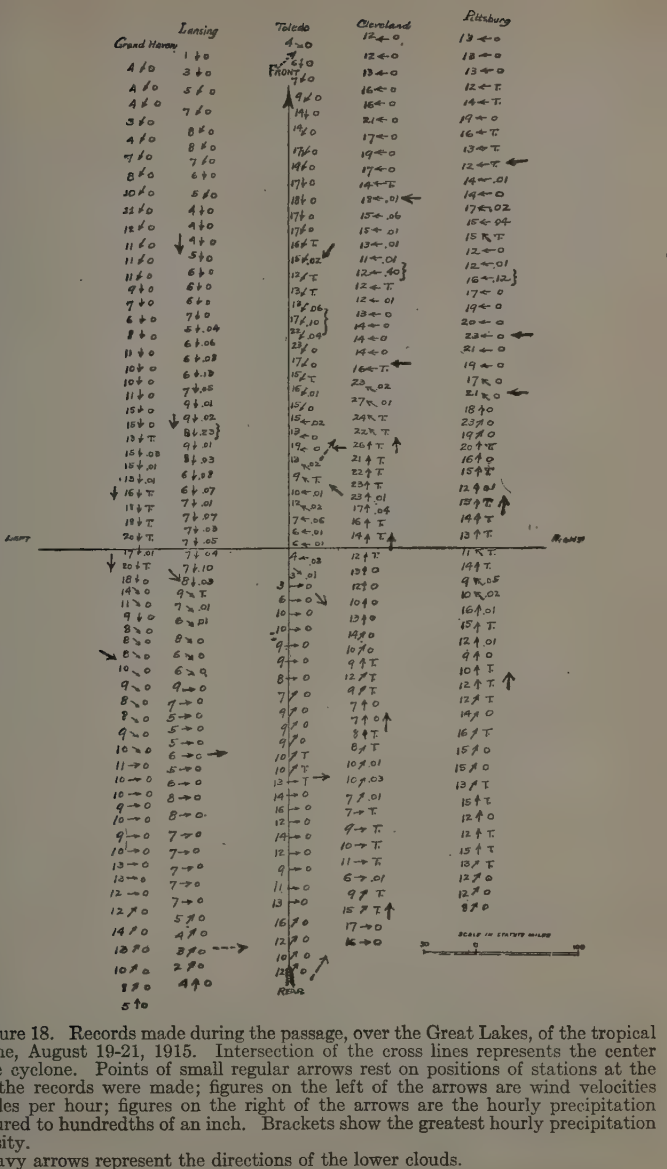


Figure 18. Records made during the passage, over the Great Lakes, of the tropical clone, August 19-21, 1915. Intersection of the cross lines represents the center the cyclone. Points of small regular arrows rest on positions of stations at the ne the records were made; figures on the left of the arrows are wind velocities miles per hour; figures on the right of the arrows are the hourly precipitation asured to hundredths of an inch. Brackets show the greatest hourly precipitation ensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of the larger traveling cyclones.

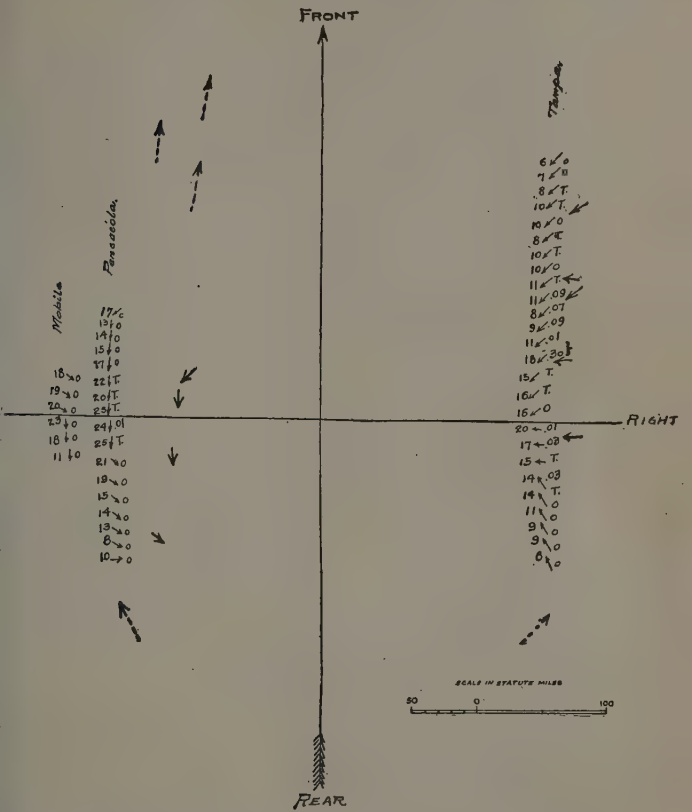
X

Tropical Cyclone on the East Gulf Coast September 2-4 1915

The hourly winds and precipitation at stations in the tropica cyclone of September 2-4, 1915, (28), are charted in Figure 20 This cyclone moved northwestward from the Caribbean Se across the western end of Cuba, curved slightly as it crosse the eastern Gulf of Mexico, and then moved northward to th Great Lakes, as shown on path "J," Figure 2. The cycloni circulation in this storm was about 350 miles in diameter. Ther were no stations with automatic records near the center o this cyclone while moving through the Gulf region. The record from Tampa, Fla., are shown at some distance from the cente in the right half, and those from Pensacola, Fla., and Mobile Ala., at some distance from the line of advance of the center i the left half of the cyclonic area.

The directions of the lower clouds differ to some extent fron the surface winds, being inclined to the right where they differ The cirrus clouds, both in the front and the rear, moved forwar in the same general direction as that in which the cyclon traveled.

OPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*



gure 20. Records made during the passage of the tropical cyclone, Septemebr 1915. Intersection of cross lines represents the center of the cyclone. Points mall regular arrows rest on positions of stations at the time the records were e; figures on the left of the arrows are wind velocities in miles per hour; the es on the right of the arrows are the hourly precipitation measured to hundredths n inch. Brackets show greatest hourly precipitation intensity.
eavy arrows represent the directions of the lower clouds.
roken arrows represent the directions of the upper clouds, the cirrus types.
his cyclone falls in the group of the smaller traveling cyclones.

XI

Tropical Cyclone on the Louisiana Coast September 28-30 1915

The cyclone of September 28-30, 1915, (18) moved from th Caribbean Sea through the Yucatan Channel in a northwesterl direction, curving slowly over the northern portion of the Gul of Mexico and southeastern Louisiana and traveling thenc northeastward with its right half over the Appalachian Plateau as shown in path "D," Figure 2. There were no high pressur areas to influence the winds and precipitation in the cyclone a it moved inland, but after it reached the elevated regions o the Appalachian Plateau, that elevation influenced both th winds and precipitation. We are able to make a very thorough study of the pressure, winds, and precipitation in the cycloni area before it came under the influence of the elevated regions Supplemental barometer readings at substations are given i Table X. The shapes of the isobars and the gradients in th different parts of the cyclonic area based on the most complet barometer readings known to have been recorded near the cente of a tropical cyclone are shown for every four hours from 4 a. m. September 29, 1915, to 8 a. m., September 30, 1915, on Figure 22 to 29, inclusive. September 29, 1915, at 4 p. m., we have th cyclonic center approaching Lockport, La., where a barometer reading of 28.07 inches was recorded at 5 p. m. Based on this we have sufficient pressure readings at 4 p. m. to establish th fact that the isobars were nearly circular from 28.1 to 29.4 inches as shown on Figure 25. Beyond the 29.4 isobar, there is a crowding of the isobars on the right side and a spreading ou with a bulge on the left side.

At 8 p. m., September 29th, Figure 26, we find the storm center a short distance west of north from New Orleans, 11 miles inland from the coast, having moved about 40 miles i four hours. The isobars are circular from 28.2 to 29.4, whil outside of the 29.4 isobar they are crowded on the right an spread out showing a bulge on the left side. There had bee no change in the intensity of the cyclone during its progress fo

2 hours previous to this time as shown by a comparison of the receding charts. The diameter of the 29.2 isobar was 124 iles. The distance between the 28.1 and the 29.2 isobars was 3 miles, giving a gradient in that distance of 1.1 inches, an verage of .02 of an inch per mile. The steepest barometric radients are not in the immediate vicinity of the cyclonic enter but are 15 to 40 miles away from the center. The radient between Tulane University, 11 miles from the cyclonic enter, and the Weather Bureau Office, New Orleans, La., was 1 of an inch in three miles. From New Orleans outward from ie center for a distance of 53 miles the gradient averaged .02 an inch per mile, six times as steep as the gradient between 1 and 14 miles from the center. The barometer at Tulane niversity remained stationary from 5.30 p. m. to 6.00 p. m. at 3.10 inches. Three other observers in the immediate vicinity Tulane University reported almost a dead calm during this eriod.

The isobars and gradients at 12 midnight, September 29-30, 915, are shown on Figure 27. There are no pressure readings ear the center of the cyclone, but the isobars remained nearly rcular up to 29.4 inches. The cyclone showed a decided de- ease in intensity during the preceding four hours, filling up at e center so that the 29.1 isobar decreased from 120 miles to miles in diameter. Outside of the 29.4 isobar the gradients ere more crowded in the front half than elsewhere and there as a spreading out in the left rear quadrant, causing a bulge that quarter. The isobars at 4 a. m. and 8 a. m., respectively, ptember 30th are shown in Figures 28 and 29. Very little ange took place during the period covered by these maps cept that the isobars assumed a more circular form up to 29.7 ches. The crowding of the isobars in one portion and spread- g out in another outside of 29.4 inches in this cyclone were the same portions of the cyclonic area as those previously ted in the cyclone of August 15-22, 1915.

The hourly wind direction, velocity, and precipitation during e passage of the cyclone of September 29-30, 1915, are shown Figure 21, for New Orleans and Burrwood, La., Mobile, Ala., d Pensacola, Fla., in the right half, and for Galveston, Texas, the left half of the cyclonic area. Detailed meteorological

data are given in Table XI. There are no automatic precipi tation records for Burrwood, La., and the wind velocity recor was lost after 9 p. m., September 29th. The wind directions i the right rear quadrant of the cyclonic area were mainly in th same direction as that in which the cyclone was traveling. I the right front quadrant the winds did not show any decide inclination towards the center, the angles varying at differen distances from the line followed by the center.

The directions of the lower clouds in the right front quadran at Pensacola and Mobile were inclined away from the cente more than the surface winds; at New Orleans the direction were about the same as the surface winds. In the right rea quadrant the lower clouds have the same general direction a the surface winds.

Cirrus clouds were recorded six times at New Orleans, La. in front of the cyclone, the first time when that station was 40 and the last when it was 300 miles in front of the center. Th shifting directions, which were carefully checked, show con siderable confusion at the cirrus level at that time. Four of th six observations showed the cirrus moving in the same genera direction as that in which the cyclone was traveling. At Pensa cola, Fla., 200 miles to the right of the line along which th center was advancing, cirrus clouds were recorded four times first 350 miles in front and last when that station was 250 mile in front of the line dividing the cyclone into front and rea halves. These cirrus had a direction across the line of advanc but were inclined in the direction in which the cyclone wa traveling. At Galveston, Texas, 250 miles to the left of th line followed by the center of the cyclone, there were eigh records of cirrus clouds all moving in the same direction as tha in which the cyclone was traveling, the first observation bein 400 miles in front and the last 100 miles in the rear of the lin dividing the cyclone into front and rear halves. There was on observation of cirrus at Pensacola, Fla., in the right rear quac rant of the cyclone with the same general direction as that i which the cyclone was traveling.

Precipitation commenced at New Orleans, September 2 when the cyclonic center was 160 miles distant in space an fifteen hours in time. *The total precipitation at New Orlear*

during the advance and passage of the front half of the cyclone was 8.20 inches, but there was only .02 of an inch in the rear half. The precipitation ceased with the passage of the cyclonic center. The greatest hourly precipitation intensity commenced at New Orleans nine hours before and ended four hours before the passage of the cyclonic center, during which time there was 4.49 inches, 55% of the total precipitation that occurred at New Orleans during the passage of the cyclone. The greatest precipitation in any hour was 1.59 inches at New Orleans, 84 miles in front and seven hours before the passage of the cyclonic center, and about 60 miles to the right of the line along which the center was advancing at that time. There was a secondary period of heavy precipitation two hours before the passage of the storm center. At Mobile, Ala., the greatest hourly precipitation intensity was from twelve to eight hours before the passage of the storm center and at Pensacola, Fla., the greatest precipitation intensity was 14 hours before the passage of the storm center. *Very little precipitation occurred at Mobile, Ala., and Pensacola, Fla., after their passage into the rear half of the cyclonic area.* About 55 miles to the northward from New Orleans, at Franklinton, La., there was 14.43 inches of precipitation, also to the right of the line along which the center was advancing, and while in the front half of the cyclone.

TABLE X

BAROMETER (ANEROID CORRECTED) READINGS AT SUBSTATIONS ON THE MIDDL GULF COAST DURING THE PASSAGE OF THE TROPICAL CYCLONE, SEPTEMBER 29-30 1915. THE DISTANCE OF THE STATIONS TO THE RIGHT OR LEFT OF THE LINE FOL LOWED BY THE CENTER OF THE CYCLONE IS GIVEN.

90th Meridian Time

DATE AND HOUR	MORGAN CITY, LA. 55 MILES TO THE LEFT	LOCKPORT, LA. CENTER PASSED OVER	TULANE UNIVERSITY, NEW ORLEANS, LA. 9 MILES TO THE RIGHT	PAULINE STREET WHARF, NEW ORLEANS, LA. 15 MILES TO THE RIGHT	BAY ST. LOUIS, MISS. 62 MILES TO THE RIGHT
SEPT. 29th					
2:30 a.m.	.....	29.70	.....	.....	.....
3:25 a.m.	.....	29.67	.....	.....	.....
3:34 a.m.	.....	29.66	.....	.....	.....
4:00 a.m.	.....	.....	.....	29.60	.....
4:30 a.m.	29.58	.....	.....	.....	.....
6:00 a.m.	.....	29.63	.....	29.53	.....
7:00 a.m.	29.56	29.58	.....	.....	.....
8:00 a.m.	29.53	.....	.....	29.53	.....
8:30 a.m.	.....	29.50	29.60	.....	.....
9:00 a.m.	29.50	29.45	.....	.....	.....
9:30 a.m.	.....	29.42	29.52	.....	.....
10:00 a.m.	29.43	.....	.....	29.41	.....
10:30 a.m.	.....	29.35	29.45	.....	29.53
11:00 a.m.	29.38	.....	29.40	.....	.....
11:30 a.m.	.....	29.26	29.30	.....	29.39
12:00 noon	29.30	29.21	29.30	29.20	.....
12:30 p.m.	.....	29.12	.....	.....	.....
1:00 p.m.	29.20	29.08	29.20	.....	.....
1:30 p.m.	.....	29.05	29.16	.....	.....
2:00 p.m.	29.10	28.99	29.12	28.96	.....
2:15 p.m.	.....	28.97	29.05	.....	.....
2:35 p.m.	.....	28.93	29.02	.....	.....
2:40 p.m.	.....	.....	29.01	.....	.....
2:45 p.m.	.....	.....	29.00	.....	.....
3:00 p.m.	29.06	28.85	28.97	28.84	29.22
3:10 p.m.	.....	28.80	28.95	.....	.....
3:15 p.m.	.....	.....	28.93	.....	.....
3:30 p.m.	.....	28.75	.....	.....	.....
3:35 p.m.	.....	28.71	28.90	.....	.....
4:00 p.m.	29.05	28.57	28.76	28.76	.....
4:30 p.m.	.....	28.39	28.65	.....	.....
4:40 p.m.	.....	28.28	.....	.....	.....
4:45 p.m.	.....	.....	28.35	.....	.....
4:50 p.m.	.....	28.07	.....	.....	.....

TABLE X

BAROMETER (ANEROID CORRECTED) READINGS AT SUBSTATIONS ON THE MIDDLE GULF COAST DURING THE PASSAGE OF THE TROPICAL CYCLONE, SEPTEMBER 29-30, 1915. THE DISTANCE OF THE STATIONS TO THE RIGHT OR LEFT OF THE LINE FOLLOWED BY THE CENTER OF THE CYCLONE IS GIVEN.

90th Meridian Time

DATE AND HOUR	MORGAN CITY, LA. 55 MILES TO THE LEFT	LOCKPORT, LA. CENTER PASSED OVER	TULANE UNIVERSITY, NEW ORLEANS, LA. 9 MILES TO THE RIGHT	PAULINE STREET WHARF, NEW ORLEANS, LA. 15 MILES TO THE RIGHT	BAY ST. LOUIS, MISS. 62 MILES TO THE RIGHT
SEPT. 29th					
5:00 p.m.	.....	28.07	.....	28.28	.....
5:15 p.m.	.....	.....	28.25	.....	.....
5:30 p.m.	29.10	28.03	28.10	.....	.....
6:00 p.m.	.....	28.06	28.10	28.04	28.94
6:40 p.m.	.....	.....	.....	28.01	.....
7:00 p.m.	.....	.....	.....	28.11	.....
8:00 p.m.	29.18	.....	.....	28.44	28.90
9:00 p.m.	29.24	29.11	.....	.....	.....
10:00 p.m.	29.31	.....	.....	28.81	.....
12:00 mid.	.....	.....	.....	29.02	.....
30th					
1:45 a.m.	.....	.....	.....	.....	29.11
3:00 a.m.	29.50	.....	.....	.....	.....
3:30 a.m.	.....	29.45	.....	.....	.....
4:30 a.m.	.....	29.53	.....	.....	.....
6:00 a.m.	.....	29.59	.....	.....	.....
7:00 a.m.	29.62	.....	.....	.....	.....
8:00 a.m.	.....	29.66	.....	.....	29.44
10:30 a.m.	.....	29.87	.....	.....	.....

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 28 TO 30, 1915

TABLE XI 90th Meridian Time

Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the left of the line followed by the center of the cyclone, 250 miles.								New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 14 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
28th								28th						ci.	sw.
10 a.m.	29.83	84	0	ne.	13	ci.	se.	1 p.m.	29.77	87	0	e.	17	ci. st.	sw.
11 a.m.	29.82	83	0	ne.	12	ci. cu. st. cu.	se. ne.							cu. ci.	e. s.
12 noon	29.81	86	0	e.	12	ci. cu.	se. ne.	2 p.m.	29.76	87	0	e.	18	ci. cu. cu. ci.	s. e. sw.
1 p.m.	29.80	84	0	e.	11										
2 p.m.	29.78	85	0	e.	13										
3 p.m.	29.77	85	0	e.	10	ci.	s.	3 p.m.	29.75	87	0	e.	18	ci. st. cu. ci.	sw. e. sw.
4 p.m.	29.77	85	0	e.	9										
5 p.m.	29.75	85	0	se.	5										
6 p.m.	29.75	84	0	se.	4	ci.	s.	4 p.m.	29.74	86	0	e.	18	ci. st.	s.
7 p.m.	29.75	84	0	se.	3	st. cu.	e.	5 p.m.	29.73	85	0	e.	16	cu.	e.
8 p.m.	29.75	83	0	e.	4			6 p.m.	29.72	84	0	e.	14		
9 p.m.	29.75	82	0	e.	5			7 p.m.	29.72	82	0	e.	14	a. cu. st. cu.	e. e.
10 p.m.	29.75	82	0	n.	6			8 p.m.	29.72	81	0	e.	16		
11 p.m.	29.75	82	0	n.	9			9 p.m.	29.71	81	0	e.	18		
12 mid.	29.75	82	0	nw.	8			10 p.m.	29.70	81	0	e.	19		
29th								11 p.m.	29.68	80	0	e.	19		
1 a.m.	29.74	82	0	n.	10			12 mid.	29.66	80	0	e.	19		
2 a.m.	29.72	81	0	n.	9			29th							
3 a.m.	29.71	81	0	n.	11			1 a.m.	29.65	80	0	ne.	17		
4 a.m.	29.70	81	0	n.	14			2 a.m.	29.64	79	0	ne.	17		
5 a.m.	29.71	80	0	n.	13			3 a.m.	29.63	80	.01	ne.	18		
6 a.m.	29.72	79	0	n.	16			4 a.m.	29.60	75	.20	e.	25		
7 a.m.	29.73	79	0	n.	16	ci. st. a. cu.	s. ne.	5 a.m.	29.58	76	.07	e.	24		
8 a.m.	29.73	80	0	n.	16			6 a.m.	29.56	76	.06	e.	25		
9 a.m.	29.72	81	0	n.	16	ci. st.	s.	7 a.m.	29.55	78	.10	e.	29	nb.	e.
10 a.m.	29.72	82	0	n.	18			8 a.m.	29.50	75	.29	e.	32		
11 a.m.	29.72	85	0	n.	17	ci. st. cu.	s. 0	9 a.m.	29.45	75	.37	ne.	35	nb.	ne.
12 noon	29.67	85	0	n.	19			10 a.m.	29.40	74	.53	ne.	37		
1 p.m.	29.66	86	0	n.	18	ci. st. cu.	s. n.	11 a.m.	29.30	74	.62	ne.	42	nb.	ne.
2 p.m.	29.65	88	0	n.	18			12 noon	29.18	74	1.59	ne.	40		
3 p.m.	29.63	90	0	n.	20			1 p.m.	29.10	76	.84	ne.	48	nb.	e.
3:30 pm	29.63	C	tr.	P	asse	d		2 p.m.	29.05	76	.91	e.	49		
4 p.m.	29.63	88	0	n.	17			3 p.m.	28.93	76	.30	e.	50	nb.	e.
5 p.m.	29.63	87	0	n.	17			4 p.m.	28.76	75	.58	e.	50		
6 p.m.	29.65	87	0	n.	19			5 p.m.	28.39	75	1.05	se.	60		

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 28 TO 30, 1915

TABLE XI 90th Meridian Time

Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the left of the line followed by the center of the cyclone, 250 miles.								New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 14 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction
29th								29th							
7 p.m.	29.66	85	0	n.	15	ci.	s.	5:50 pm	28.11	73	Ctr.	Pas	sed	nb.	se.
8 p.m.	29.68	84	0	n.	16	a. st.	0	6 p.m.	28.14	74	.60	se.	62		
9 p.m.	29.69	83	0	n.	17			7 p.m.	28.31	76	T.	se.	41	st.	s.
0 p.m.	29.70	82	0	n.	17			8 p.m.	28.70	75	.01	sw.	33		
1 p.m.	29.70	81	0	n.	19			9 p.m.	28.91	74	.01	sw.	27		
2 mid.	29.70	80	0	n.	19			10 p.m.	29.04	73	T.	sw.	22		
30th								11 p.m.	29.14	72	T.	sw.	26		
1 a.m.	29.70	80	0	n.	19			12 mid.	29.20	73	T.	sw.	30		
2 a.m.	29.71	79	0	n.	19			30th							
3 a.m.	29.71	79	0	n.	20			1 a.m.	29.27	75	0	sw.	29		
4 a.m.	29.72	78	0	n.	19			2 a.m.	29.33	76	0	sw.	29		
5 a.m.	29.74	77	0	n.	19			3 a.m.	29.40	76	0	sw.	27		
6 a.m.	29.76	76	0	n.	17			4 a.m.	29.45	74	0	sw.	26		
7 a.m.	29.77	76	0	n.	15	ci.	0	5 a.m.	29.51	74	0	sw.	22		
8 a.m.	29.79	75	0	nw.	10	st.	n.	6 a.m.	29.55	73	0	sw.	18		
9 a.m.	29.80	77	0	nw.	12			7 a.m.	29.58	74	0	sw.	16	st.	sw.
0 a.m.	29.80	78	0	nw.	13			8 a.m.	29.60	75	0	sw.	16		
								9 a.m.	29.63	77	0	sw.	12		
								10 a.m.	29.65	78	0	w.	11		
								11 a.m.	29.67	79	0	w.	10		
								12 noon	29.68	80	0	w.	9		
								1 p.m.	29.67	80	0	w.	9		

TABLE XI — TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 28 TO 30, 1915
90th Meridian Time

Burrwood, Louisiana.

Latitude 28° 58′ N. Longitude 89° 23′ W. To the right of the line followed by the center of the cyclone, 60 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
28th						
4 a.m.				13		
5 a.m.				12		
6 a.m.				12		
7 a.m.				12		
8 a.m.	29.79		ne.	15		
9 a.m.				20		
10 a.m.				24		
11 a.m.				24		
12 noon				26		
1 p.m.	29.74		ne.	28		
2 p.m.	29.71		ne.	28		
3 p.m.				30		
4 p.m.	29.69		ne.	32		
5 p.m.				31		
6 p.m.				30		
7 p.m.				30		
8 p.m.	29.64		ne.	34		
9 p.m.				37		

Mobile, Alabama.

Latitude 30° 41′ N. Longitude 88° 02′ W. To the right of the line followed by the center of the cyclone, 130 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
29th							
1 a.m.	29.77	78	0	e.	18		
2 a.m.	29.77	78	0	e.	19		
3 a.m.	29.75	79	0	e.	21		
4 a.m.	29.73	80	0	e.	24		
5 a.m.	29.72	80	0	e.	25		
6 a.m.	29.71	79	T.	e.	27		
7 a.m.	29.71	79	T.	e.	25	st.	se.
8 a.m.	29.71	79	T.	e.	26		
9 a.m.	29.66	79	.01	e.	25	st.	se.
10 a.m.	29.70	79	.16	e.	22		
11 a.m.	29.69	72	.56	e.	27	st.	se.
12 noon	29.65	76	T.	e.	25		
1 p.m.	29.62	78	.03	e.	30	st.	se.
2 p.m.	29.60	77	.09	e.	36		
3 p.m.	29.60	76	.26	e.	36		
4 p.m.	29.56	77	.39	se.	33		
5 p.m.	29.55	79	.04	se	37		
6 p.m.	29.55	77	.37	se.	37		

Pensacola, Florida.

Latitude 30° 35′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 175 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
28th							
8 p.m.	29.82	77	0	ne.	16		
9 p.m.	29.80	79	0	e.	20		
10 p.m.	29.80	79	0	e.	21		
11 p.m.	29.79	79	0	e.	23		
12 mid.	29.78	80	0	e.	31		
29th							
1 a.m.	29.77	80	0	e.	37		
2 a.m.	29.75	80	0	e.	38		
3 a.m.	29.76	79	0	e.	32		
4 a.m.	29.75	79	0	e.	32		
5 a.m.	29.76	76	.08	e.	31		
6 a.m.	29.76	79	.02	e.	31		
7 a.m.	29.76	79	T.	e.	34	st.	se.
8 a.m.	29.76	79	T.	e.	32		
9 a.m.	29.76	80	T.	e.	38	st.	se.
10 a.m.	29.74	81	T.	e.	43	nb.	se.
11 a.m.	29.73	76	.06	se.	42		
12 noon	29.73	78	.13	se.	37		

Burrwood, Louisiana.
Latitude 28° 58′ N. Longitude 89° 23′ W.
To the right of the line followed by the center of the cyclone, 60 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
28th						
11 p.m.				39		
12 mid.				43		
29th						
1 a.m.				49		
2 a.m.				46		
3 a.m.	29.42			55		
4 a.m.	29.38			60		
5 a.m.	29.30			65		
6 a.m.	29.23		ene.	72		
7 a.m.	29.18			76		
8 a.m.	29.09		ene.	80		
9 a.m.	29.00			84		
10 a.m.	29.04		ese.	86		
11 a.m.				84		
12 noon	29.05		ese.	81		
1 p.m.				85		
2 p.m.	29.09		sse.	79		
3 p.m.				78		

Mobile, Alabama.
Latitude 30° 41′ N. Longitude 88° 02′ W.
To the right of the line followed by the center of the cyclone, 130 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
29th							
8 p.m.	29.55	81	.03	se.	46		
9 p.m.	29.54	80	.02	se.	50		
10 p.m.	29.53	75	.16	se.	50		
11 p.m.	29.52	75	.11	se.	44		
12 mid.	29.51	80	.10	se.	44		
30th							
1 a.m.	29.50	76	.23	se.	42		
2 a.m.	29.48	78	T.	s.	42		
2:45 am	29.45	C	ent	er P	asse	d	
3 a.m.	29.45	81	T.	s.	38		
4 a.m.	29.47	75	.23	s.	39		
5 a.m.	29.48	78	.12	s.	41		
6 a.m.	29.53	81	.12	s.	40		
7 a.m.	29.57	75	.06	sw.	29	a. st.	sw.
8 a.m.	29.58	79	T.	sw.	33	st.	sw.
9 a.m.	29.58	80	0	sw.	33		
10 a.m.	29.58	81	0	sw.	33		
11 a.m.	29.59	81	0	sw.	33	st.	sw.

Pensacola, Florida.
Latitude 30° 35′ N. Longitude 87° 13′ W.
To the right of the line followed by the center of the cyclone, 175 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
29th							
2 p.m	29.70	80	T.	se.	42		
3 p.m.	29.67	80	0	se.	45		
4 p.m.	29.64	78	.12	se.	43		
5 p.m.	29.63	82	.01	se.	42		
6 p.m.	29.63	77	.02	se.	45		
7 p.m.	29 63	82	0	se.	47	st. cu.	s.
8 p.m.	29.64	82	0	se.	49		
9 p.m.	29.64	80	.01	se.	50		
10 p.m.	29.64	79	.01	se.	49		
11 p.m.	29.63	80	T.	se.	50		
12 mid.	29.61	80	T.	se.	54		
30th							
1 a.m.	29.61	80	T.	se.	50		
2 a.m.	29.61	78	T.	s.	58		
2:30 am	29.60	C	ent	er P	asse	d	
3 a.m.	29.61	80	T.	s.	54		
4 a.m.	29.62	80	T.	s.	55		
5 a.m.	29.64	78	.02	s.	51		

TABLE XI

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 28 TO 30, 1915
90th Meridian Time

Burrwood, Louisiana.
Latitude 28° 58′ N. Longitude 89° 23′ W.
To the right of the line followed by the center of the cyclone, 60 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
29th						
4 p.m.	29.17		sse.	108		
5 p.m.				107		
6 p.m.	29.23		sw.	95		
7 p.m.	29.31		ssw.	77		
8 p.m.	29.37		wsw.	62		
9 p.m.	29.52		s.	50		
10 p.m.	29.54		s.	44		
11 p.m.						
12 mid.	29.58		ssw.			
30th						
1 a.m.						
2 a.m.			ssw.			
3 a.m.						
4 a.m.			ssw.			
5 a.m.						
6 a.m.			ssw.			
7 a.m.						
8 a.m.			ssw.			

Mobile, Alabama.
Latitude 30° 41′ N. Longitude 88° 02′ W.
To the right of the line followed by the center of the cyclone, 130 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
30th							
12 noon	29.59	82	0	sw.	31		
1 p.m.	29.61	81	0	sw.	30		
2 p.m.	29.65	80	0	sw.	22		
3 p.m.	29.69	80	0	sw.	21		
4 p.m.	29.71	80	0	sw.	18		
5 p.m.	29.72	79	0	sw.	13		
6 p.m.	29.73	79	0	sw.	8		
7 p.m.	29.74	78	0	sw.	7	st.	sw.
8 p.m.	29.75	78	0	sw.	6		
9 p.m.	29.77	78	0	sw.	5		
10 p.m.	29.78	77	0	sw.	8		
11 p.m.	29.79	77	0	sw.	7		
12 mid.	29.80	75	0	w.	5		

Pensacola, Florida.
Latitude 30° 35′ N. Longitude 87° 13′ W.
To the right of the line followed by the center of the cyclone, 175 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
30th							
6 a.m.	29.64	80	.02	s.	50	ci. st.	sw.
7 a.m.	29.65	81	0	s.	48	a. st.	sw.
8 a.m.	29.66	82	0	s.	46	st. cu.	sw.
9 a.m.	29.67	76	0	s.	48		
10 a.m.	29.67	77	.12	sw.	49		
11 a.m.	29.67	80	0	sw.	46		
12 noon	29.66	81	0	sw.	43		
1 p.m.	29.67	80	.01	sw.	39		
2 p.m.	29.67	81	0	sw.	35		
3 p.m.	29.66	82	0	sw.	34		
4 p.m.	29.68	81	0	sw.	33		
5 p.m.	29.71	81	0	sw.	28		
6 p.m.	29.73	80	0	sw.	22		
7 p.m.	29.75	79	0	sw.	16	st. cu.	sw.
8 p.m.	29.77	78	0	w.	13		

Figure 21. Records made during the passage of the tropical cyclone, September 27–30, 1915. Intersection of cross lines represents the center of the cyclone. Points of small regular arrows rest on positions of stations at the time the records were made; figures on the left of the arrows are wind velocities in miles per hour; figures on the right of the arrows are the hourly precipitation measured to hundredths of an inch. Brackets show greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of the larger traveling cyclones.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

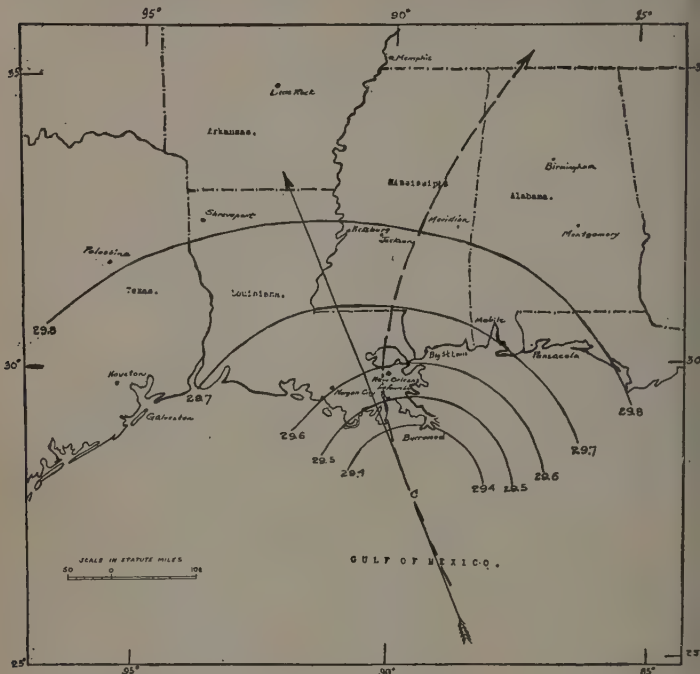


Figure 22. Pressure distribution, 4:00 a.m., September 29, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center.

Solid line with arrow indicates the direction of movement of the cyclonic center at 4:00 a.m.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

Figure 23. Pressure distribution, 8:00 a.m., September 29, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center.

Solid line with arrow indicates direction of movement of the cyclonic center at 8:00 a.m.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

Figure 24. Pressure distribution, 12 noon, September 29, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center.

Solid line with arrow indicates direction of movement of the cyclonic center at 12 noon.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

Figure 25. Pressure distribution, 4:00 p.m., September 29, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at 4:00 p.m.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

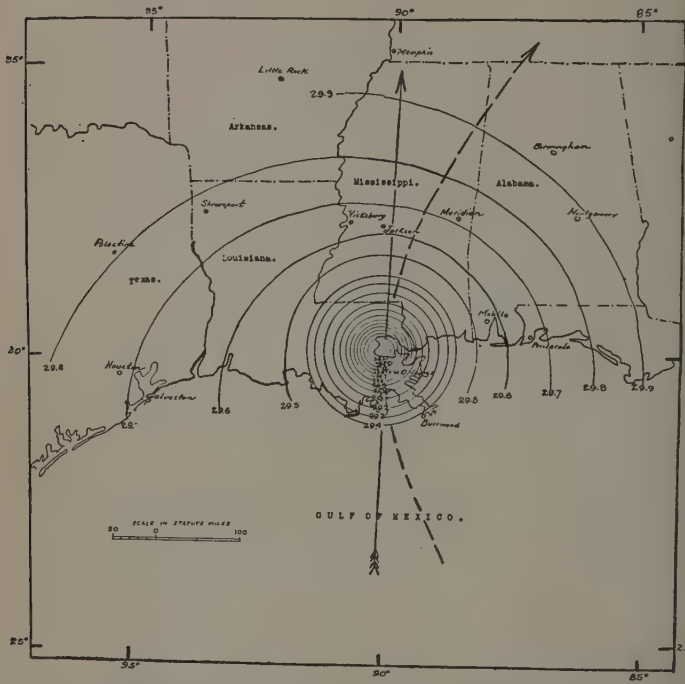


Figure 26. Pressure distribution, 8:00 p.m., September 29, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at 8:00 p.m.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

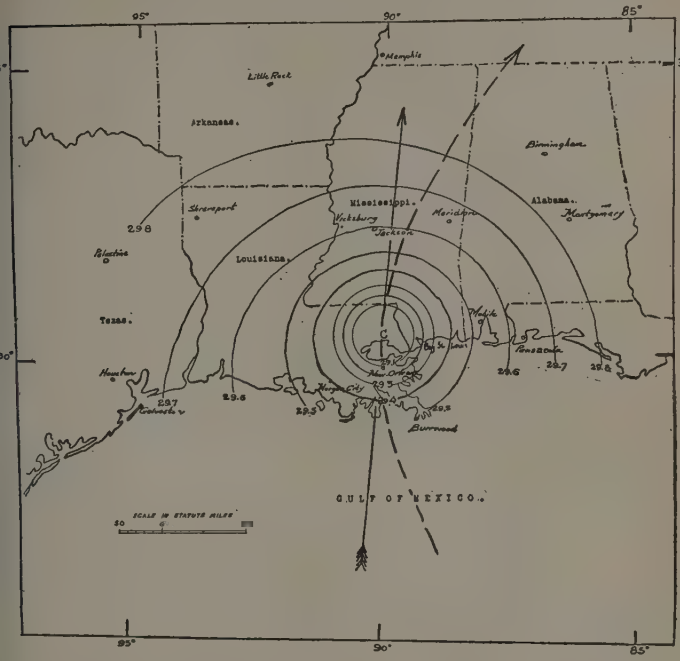


Figure 27. Pressure distribution, 12 midnight, September 29–30, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at 12 midnight.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

Figure 28. Pressure distribution, 4:00 a.m., September 30, 1915, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at 4:00 a.m.

ROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

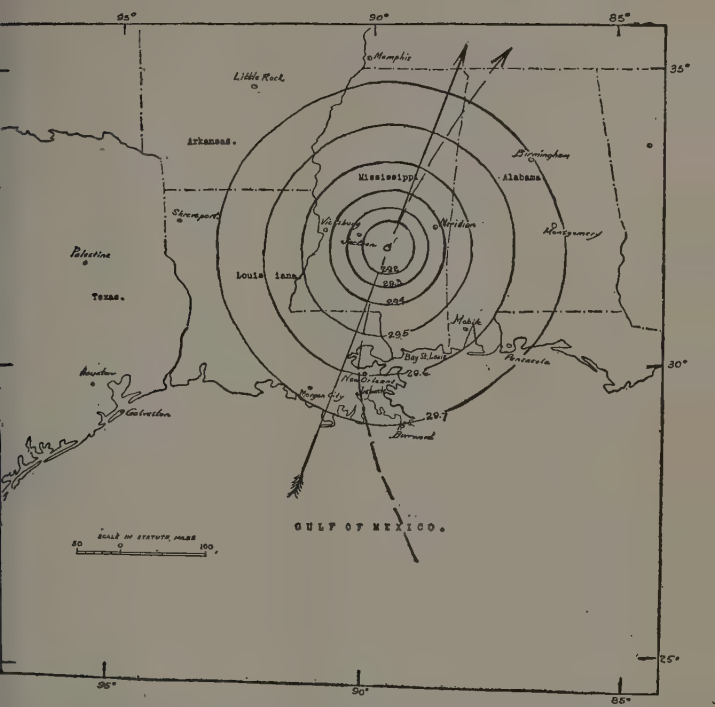


Figure 29. Pressure distribution, 8:00 a.m., September 30, 1915, 75th Meridian ime. Isobars are drawn for each .10 of an inch. Broken line is path followed y the cyclonic center. Solid line with arrow indicates the direction of movement f the cyclonic center at 8:00 a.m.

XII

Tropical Cyclone on the Middle Gulf Coast July 4-6, 1916

The tropical cyclone of July 4-6, 1916, (19), moved through the Yucatan Channel and thence across the Gulf of Mexico to the Mississippi Coast as shown in path "L," Figure 2. This cyclone ceased to advance soon after moving inland and remained nearly stationary over Mississippi and Alabama from July 6th to 10th, gradually filling up and dying out. Detailed meteorological data recorded during the passage of this cyclone are shown in Table XII. The hourly wind directions and velocities and precipitation during the passage of this cyclone for New Orleans, La., in the left half, and Mobile, Ala., and Pensacola, Fla., in the right half of the cyclonic area are shown in Figure 30. The winds in the right rear quadrant were continuously in the same general direction as that in which the cyclonic center was advancing. In the other quadrants the wind directions were around the center without any well defined characteristics.

There was considerable confusion in the region of the lower clouds in this cyclone but the directions fall in mainly with the surface winds. The cirrus clouds both in the front and rear moved from left to right somewhat across the line of advance of the cyclonic area, following mainly the prevailing direction of the cirrus in this latitude. Well in front of the cyclone one observation of cirrus at Mobile, Ala., had a direction slightly inclined against the direction in which the cyclone was traveling.

The distribution of the hourly precipitation was not confined to any particular part of the cyclonic area and was similar to that in the tropical cyclone of August 26-28, 1911, which ceased to advance and died out or filled up soon after moving inland. Precipitation did not extend far in advance of this cyclone. Rain commenced at both Pensacola, Fla., and Mobile, Ala., only about ten hours in time and 100 miles in space in advance of the cyclonic center.

The greatest hourly precipitation intensity at Pensacola occurred with the passage of the cyclonic center. The greatest

ourly precipitation intensity at Mobile, Ala., occurred six to ight hours after the occurrence of the lowest barometer, and here was another period of increased precipitation intensity ighteen hours after the passage of the cyclonic center. The otal precipitation at Mobile before the passage of the cyclonic enter was 2.18 inches, and during the 20 hours after the passage f the center, 6.58 inches. Light rain with high winds occurred t Pensacola, Fla., 20 hours after the occurrence of the lowest arometer. At New Orleans, 50 miles to the left of the line of dvance of the center, light precipitation occurred in the left ear quadrant at intervals for 24 hours after the passage of the torm center.

The stations having heavy rain are given in Table XII-a eading from the Gulf Coast northward towards the interior of labama. Heavy rains continued through three days in south-estern Alabama. These records show that the heavy rains hich appeared at Mobile on the 6th, extended to central Ala-ama on the 6th and 7th, and then moved back towards the ast, into southern Alabama on the 8th. The greatest precipi-ation at any station in 24 hours occurred near the coast on the th, namely 9.87 inches at Healing Springs, and 9.00 inches t Ozark.

The air current in which the cyclone was traveling evidently ncountered an air current moving in an opposing direction; the ounter current checked the forward movement of the air ream from which rain was falling and forced it back into the ear of the cyclone and caused the precipitation to occur in ll parts of the cyclonic area; the heaviest rainfall, which ap-eared first in front of the cyclone as it moved inland on the 5th nd 6th, shifted to the rear on the 7th and 8th. The center f low pressure moved northward during the 6th into central lississippi, then it drifted over to the heavy precipitation in entral Alabama on the 7th. The cyclonic area remained nearly tationary over Alabama while the region of greatest intensity f precipitation was drifting southward, and as the precipita-on shifted to the rear of the cyclonic center, the cyclone gradu-lly filled up and died out.

TROPICAL CYCLONE ON THE MIDDLE GULF COAST. JULY 4 TO 6, 1916

TABLE XII 90th Meridian Time

New Orleans, Louisiana
Latitude 29° 58′ N. Longitude 90° 04′ W.
To the left of the line followed by the center of the cyclone, 60 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
4th							
1 p.m.	29.79	85	0	se.	10		
2 p.m.	29.76	86	0	se.	8	a. st.	w.
3 p.m.	29.74	87	0	se.	11	st. cu.	se.
4 p.m.	29.74	78	.01	se.	14		
5 p.m.	29.74	80	0	se.	6		
6 p.m.	29.74	81	0	e.	7	ci. st.	sw.
7 p.m.	29.73	81	0	e.	7	st.	ne.
8 p.m.	29.74	80	0	ne.	9		
9 p.m.	29.75	79	0	ne.	9		
10 p.m.	29.75	78	0	ne.	8		
11 p.m.	29.75	77	0	ne.	14		
12 mid.	29.70	79	0	ne.	12		
5th							
1 a.m.	29.68	79	0	ne.	11		
2 a.m.	29.67	79	0	ne.	14		
3 a.m.	29.65	79	0	ne.	15		
4 a.m.	29.62	79	0	ne.	15		
5 a.m.	29.59	79	0	ne.	17		
6 a.m.	29.58	79	0	ne.	15	a. st.	e.
7 a.m.	29.58	80	0	ne.	17	st.	ne.
8 a.m.	29.56	80	T.	ne.	18		
9 a.m.	29.54	80	0	n.	20	cu.	ne.
10 a.m.	29.52	82	T.	n.	16	st.	ne.
11 a.m.	29.53	83	T.	n.	20		
12 noon	29.49	83	T.	n.	20		
1 p.m.	29.47	82	T.	nw.	24	st.	n.
2 p.m.	29.45	82	.01	nw.	27		
3 p.m.	29.43	83	T.	nw.	26	st. cu.	n.
4 p.m.	29.43	83	0	nw.	27		
5 p.m.	29.42	80	T.	nw.	29		
5:15 pm	29.41	Cent	er P	asse	d		
6 p.m.	29.42	81	T.	nw.	23		
7 p.m.	29.43	77	.07	nw.	25	nb.	nw.
8 p.m.	29.46	80	T.	nw.	22		
9 p.m.	29.49	78	.02	nw.	19		
10 p.m.	29.52	77	.02	nw.	19		

Burrwood, Louisiana
Latitude 28° 58′ N. Longitude 89° 23′ W.
To the left of the line followed by the center of the cyclone, 25 miles.

Date and Hour	Pressure Inches (Sea Level)	Wind Direction	Wind Velocity Miles Per Hour
4th			
11 a.m.			12
12 noon	29.79	e.	12
1 p.m.	29.78	ne.	13
2 p.m.	29.76	ne.	17
3 p.m.	29.72	ne.	9
4 p.m.	29.72	ne.	14
5 p.m.	29.68	ne.	16
6 p.m.	29.66	n.	15
7 p.m.	29.65	n.	18
8 p.m.	29.65	n.	17
9 p.m.	29.64	n.	16
10 p.m.		n.	20
11 p.m.	29.60	n.	23
12 mid.	29.53	n.	24
5th			
1 a.m.	29.50	n.	24
2 a.m.	29.47	n.	28
3 a.m.	29.42	n.	31
4 a.m.			33
5 a.m.			36
6 a.m.			42
7 a.m.			27
8 a.m.			30
9 a.m.			58
10 a.m.			60
11 a.m.	29.35		57
12 noon			57
1 p.m.			57
2 p.m.			56
3 p.m.			46
4 p.m.			46
5 p.m.			43
6 p.m.			40
7 p.m.	29.58	sw.	38
8 p.m.			35
9 p.m.			36

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, JULY 4 TO 6, 1916

ABLE XII 90th Meridian Time

New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the left of the line followed by the center of the cyclone, 60 miles.								Burrwood, Louisiana. Latitude 28° 58′ N. Longitude 89° 23′ W. To the left of the line followed by the center of the cyclone, 25 miles.			
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction	Date and Hour	Pressure Inches (Sea Level)	Wind Direction	Wind Velocity Miles Per Hour
5th								5th			
p.m.	29.52	78	T.	w.	15			10 p.m.			30
mid.	29.52	78	T.	sw.	19			11 p.m.			28
6th								12 mid.			35
a.m.	29.55	78	0	sw.	16			6th			
a.m.	29.59	77	0	sw.	18			1 a.m.			32
a.m.	29.62	76	0	sw.	19			2 a.m.			28
a.m.	29.63	76	0	sw.	17			3 a.m.			37
a.m.	29.67	76	0	sw.	16			4 a.m.			26
a.m.	29.70	77	0	sw.	16			5 a.m.			25
a.m.	29.72	77	T.	sw.	14	st.	w.	6 a.m.			24
a.m.	29.77	80	T.	sw.	14			7 a.m.	29.81	s.	21
a.m.	29.79	82	0	sw.	14			8 a.m.			23
a.m.	29.79	88	0	sw.	14			9 a.m.			22
a.m.	29.79	84	0	sw.	20	ci. st.	w.	10 a.m.			22
noon	29.81	80	.02	sw.	19	cu.	sw.	11 a.m.			20
p.m.	29.81	84	0	sw.	13			12 noon			20
p.m.	29.81	84	0	sw.	15			1 p.m.			29
p.m.	29.80	84	.06	sw.	13			2 p.m.			21
p.m.	29.79	84	0	sw.	14			3 p.m.			20
p.m.	29.79	82	0	sw.	14			4 p.m.			18

TABLE XII — TROPICAL CYCLONE ON THE MIDDLE GULF COAST, JULY 4 TO 6, 1916

90th Meridian Time

Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the right of the line followed by the center of the cyclone, 60 miles.								Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 90 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction
4th								4th							
5 p.m.	29.76	78	0	e.	7			5 p.m.	29.77	79	0	se.	12	a. st.	sw.
6 p.m.	29.76	79	0	e.	5	ci. st.	0	6 p.m.	29.76	78	0	s.	9	st. cu.	e.
7 p.m.	29.76	78	0	ne.	6	a. st.	0	7 p.m.	29.76	78	0	e.	5		
8 p.m.	29.76	74	0	ne.	7	st.	se.	8 p.m.	29.76	79	0	ne.	11		
9 p.m.	29.77	74	0	n.	11			9 p.m.	29.76	81	0	ne.	15		
10 p.m.	29.76	74	0	ne.	10			10 p.m.	29.76	81	0	ne.	21		
11 p.m.	29.75	75	0	ne.	13			11 p.m.	29.75	81	0	ne.	24		
12 mid.	29.73	76	0	ne.	13			12 mid.	29.72	81	0	ne.	25		
5th								5th							
1 a.m.	29.70	77	0	ne.	12			1 a.m.	29.71	80	T.	ne.	25		
2 a.m.	29.69	78	0	ne.	13			2 a.m.	29.68	80	T.	e.	28		
3 a.m.	29.67	78	0	ne.	13			3 a.m.	29.67	80	0	e.	33		
4 a.m.	29.63	78	0	ne.	16			4 a.m.	29.65	78	T.	e.	39		
5 a.m.	29.61	78	T.	ne.	17			5 a.m.	29.63	75	.05	e.	37		
6 a.m.	29.60	76	T.	ne.	23			6 a.m.	29.61	75	.10	ne.	42		
7 a.m.	29.59	76	.02	ne.	22	st.	e.	7 a.m.	29.58	76	.02	e.	45	nb.	e.
8 a.m.	29.57	75	.05	ne.	28			8 a.m.	29.55	75	.35	ne.	46	nb.	se.
9 a.m.	29.52	73	.13	ne.	34	st.	ne.	9 a.m.	29.55	76	.34	e.	49		
10 a.m.	29.50	73	.18	ne.	34	st.	ne.	10 a.m.	29.50	76	.05	e.	67	nb.	se.
11 a.m.	29.44	73	.20	ne.	36			11 a.m.	29.48	75	.10	e.	77		
12 noon	29.38	73	.42	ne.	38			12 noon	29.43	75	.29	se.	83		
1 p.m.	29.23	73	.24	ne.	58	st.	e.	1 p.m.	29.35	76	.13	se.	91	nb.	se.
2 p.m.	29.06	74	.46	ne.	68			1:30 pm	29.31	Center Passed					
3 p.m.	28.93	74	.12	e.	89			2 p.m.	29.35	75	.50	se.	92		
3:45 pm	28.92	Center Passed						3 p.m.	29.35	75	.27	se.	79	nb.	se.
4 p.m.	28.93	75	.16	e.	99			4 p.m.	29.34	79	.08	se.	81		
5 p.m.	28.97	74	.30	se.	81			5 p.m.	29.40	75	.08	se.	80		
6 p.m.	29.01	74	.32	se.	88			6 p.m.	29.46	76	.02	s.	78		
7 p.m.	29.04	74	.33	se.	91	st.	se.	7 p.m.	29.50	74	.04	s.	68	nb.	s.
8 p.m.	29.12	74	.34	se.	84			8 p.m.	29.53	76	.02	s.	66		
9 p.m.	29.16	74	.51	se.	67			9 p.m.	29.59	76	T.	s.	62		
10 p.m.	29.30	75	.51	se.	59			10 p.m.	29.60	76	.08	s.	63		
11 p.m.	29.41	75	.63	se.	56			11 p.m.	29.63	77	.01	s.	69		
12 mid.	29.47	75	.90	s.	55			12 mid.	29.67	76	.02	s.	72		
6th								6th							
1 a.m.	29.55	76	.75	s.	40			1 a.m.	29.70	77	.01	s.	58		

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, JULY 4 TO 6, 1916

ABLE XII 90th Meridian Time

Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the right of the line followed by the center of the cyclone, 60 miles.								Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the right of the line followed by the center of the cyclone, 90 miles.							
DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS		DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION							KIND	DIRECTION
6th								6th							
a.m.	29.61	77	.13	se.	40			2 a.m.	29.71	77	.01	s.	59		
a.m.	29.67	77	.10	se.	40			3 a.m.	29.72	77	.04	s.	55		
a.m.	29.68	77	.15	s.	40			4 a.m.	29.75	77	.03	s.	56		
a.m.	29.66	78	.15	s.	40			5 a.m.	29.77	79	.01	s.	54		
a.m.	29.72	78	.19	s.	40			6 a.m.	29.80	79	T.	s.	52		
a.m.	29.78	75	.05	s.	38	st.	sw.	7 a.m.	29.83	77	T.	s.	51	st. cu.	sw.
a.m.	29.80	76	.34	s.	39			8 a.m.	29.84	78	T.	s.	49		
a.m.	29.82	76	.20	.	40			9 a.m.	29.85	80	.03	s.	50		
a.m.	29.82	77	.54	s.	35			10 a.m.	29.87	80	T.	s.	48		
a.m.	29.82	77	.12	s.	32			11 a.m.	29.89	80	0	s.	46		
noon	29.82	79	.01	s.	30			12 noon	29.90	81	0	s.	43		
p.m.	29.82	79	T.	s.	31			1 p.m.	29.90	79	T.	s.	41		
p.m.	29.83	80	.01	s.	29			2 p.m.	29.89	81	.01	s.	37		
p.m.	29.84	81	0	s.	29			3 p.m.	29.89	81	0	s.	36		
p.m.	29.84	79	0	s.	29			4 p.m.	29.89	81	0	s.	34		
p.m.	29.84	79	0	s.	28			5 p.m.	29.89	80	0	s.	32		
p.m.	29.85	79	0	s.	25			6 p.m.	29.90	80	0	s.	30		
p.m.	29.85	79	0	s.	22	st.	s.	7 p.m.	29.92	80	0	s.	28	st. cu.	s.
p.m.	29.86	78	0	s.	23										
p.m.	29.82	78	0	s.	23										

TABLE XII-a

HEAVY PRECIPITATION IN ALABAMA, JULY 5 TO 9, 1916, IN A DYING CYCLONE. STATIONS FROM THE COAST INLAND READING DOWNWARD.

90th Meridian Time

STATION	July 5th		July 6th		July 7th		July 8th		July 9th	
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
Mobile**		5.82		2.74		4.99				
Bermuda				8.00		2.30		2.65		
Healing Spring					6.10		9.87		1.45	
Ozark							9.00		1.20	
Thomasville			4.70		5.20		3.36			
Uniontown				5.95		6.80				
Goodwater					8.05		3.17			
Calera					7.00		3.17			
Tuscaloosa					8.37		1.90			
Birmingham**				4.58		7.02				
Cordova				3.38		6.25				

**Midnight to midnight, other stations either at 7 a.m. or (p.m.) about sunset.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

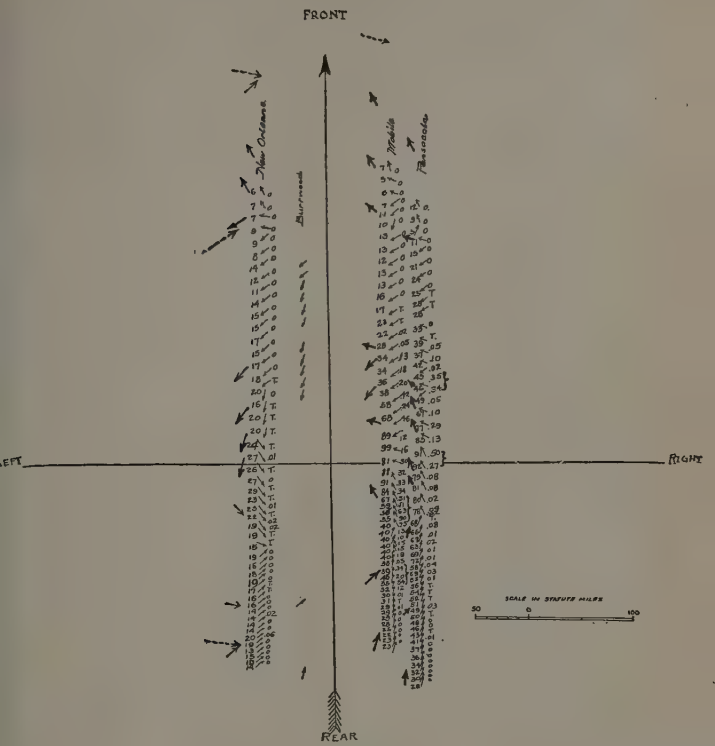


Figure 30. Records made during the passage of the tropical cyclone, July 5–7, 1916. Intersection of cross lines represents the center of the cyclone. Points of small regular arrows rest on positions of stations at the time the records were made; figures on the left of the arrows are wind velocities in miles per hour; figures on the right of the arrows are the hourly precipitation measured to hundredths of an inch. Brackets show the greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of the smaller cyclones which ceased to advance on moving inland.

XIII

Tropical Cyclone on the South Atlantic Coast July 12-15, 1916

Meteorological data recorded during the passage of the cyclone of July 12-15, 1916 (29), are shown in Table XIII. This disturbance moved in from the Atlantic Ocean and passed inland on the coast about 25 miles north of Charleston, S. C., as shown by path "M" in Figure 2. This cyclone ceased to advance soon after moving inland and died out over the interior of the Carolinas. At 8 a. m., July 15th, it appeared as a weak low pressure area over western North Carolina and on the morning of the 16th it had completely disappeared. The distribution of the hourly wind directions and velocities, and hourly precipitation as related to the cyclonic center and its direction of movement at Savannah, Ga., and Charleston, S. C., in the left half, and Wilmington, N. C., in the right half of the cyclonic area are shown in Figure 31. In this cyclone the wind directions in the front and left portions of the cyclonic area showed a movement around the cyclonic center with varying inclinations towards the center while those in the right rear quadrant were mainly in the line of advance of the cyclonic center.

The directions of the lower clouds in this cyclone are somewhat confused but they are mostly the same as the surface winds. The directions of the upper clouds observed both in the front and the rear, are somewhat opposed to the direction in which the cyclone was advancing when it moved inland.

Very little precipitation occurred in the front of the cyclone as compared with the amounts in the rear half. There was a period of increased rainfall intensity at Charleston, S. C., 16 hours in advance of the cyclonic center when .69 inch was recorded in two hours, or 45% of the total precipitation which occurred at this station in front of the cyclone.

The precipitation at both Charleston and Wilmington in the cyclone of July 12-15, 1916, was greater in the rear half than in the front half of the cyclonic area. Charleston was about 25 miles to the left of the line of advance of the center, and

the total rainfall in the front half of the cyclone was 2.88 inches. The greatest hourly precipitation intensity at Charleston occurred from 5 a. m. to 8 a. m., July 15th, 24 hours after the passage of and nearly 200 miles in the rear of the cyclonic center. At this time the cyclone was centered over western North Carolina.

Heavy rains fell in South Carolina July 15th, some 200 miles in the rear of the cyclonic center at that time, and in North Carolina on the 15th and 16th, some of the stations being in front and others in the rear of the cyclonic area. The amounts of precipitation are given in Table XIII-a.

The heavy precipitation occurred in all portions of the cyclonic area and this disturbance acted in a manner similar to the two preceding cyclones in which the precipitation occurred in all parts of the cyclonic area, when they ceased to advance and died out.

TABLE XIII

TROPICAL CYCLONE ON THE SOUTH ATLANTIC COAST JULY 13 TO 15, 1916
75th Meridian Time

Savannah, Georgia.
Latitude 32° 05′ N. Longitude 81° 05′ W.
To the left of the line followed by the center of the cyclone, 100 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
13th							
1 a.m.	30.03	74	0	n.	9		
2 a.m.	30.01	74	0	ne.	9		
3 a.m.	29.99	74	0	ne.	8		
4 a.m.	29.96	74	0	n.	8		
5 a.m.	29.96	73	0	n.	9		
6 a.m.	29.97	73	0	n.	9		
7 a.m.	29.97	75	0	n.	13	ci. st.	ne.
8 a.m.	29.96	76	0	n.	13	a. st.	ne.
9 a.m.	29.95	79	0	n.	14	st.	ne.
10 a.m.	29.95	80	0	n.	18	a. cu.	n.
11 a.m.	29.92	82	0	n.	17	cu.	ne.
12 noon	29.88	84	0	n.	22		
1 p.m.	29.86	85	0	n.	24		
2 p.m.	29.84	72	.01	n.	26	st. cu.	ne.
3 p.m.	29.83	74	.05	ne.	17	a. cu.	ne.
4 p.m.	29.78	73	.02	n.	23	st. cu.	ne.
5 p.m.	29.76	74	0	n.	21		
6 p.m.	29.75	75	0	nw.	30		
7 p.m.	29.74	75	0	nw.	30	ci. st.	0

Charleston, South Carolina.
Latitude 32° 47′ N. Longitude 79° 56′ W.
To the left of the line followed by the center of the cyclone, 25 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
13th							
1 a.m.	30.01	76	0	ne.	14		
2 a.m.	29.98	76	0	ne.	12		
3 a.m.	29.97	76	0	ne.	11		
4 a.m.	29.96	77	0	ne.	13		
5 a.m.	29.95	77	0	ne.	17		
6 a.m.	29.95	78	0	ne.	20		
7 a.m.	29.96	79	0	ne.	21		
8 a.m.	29.95	80	0	ne.	16	st.	ne.
9 a.m.	29.93	81	0	ne.	22		
10 a.m.	29.92	83	0	ne.	28		
11 a.m.	29.91	83	0	ne.	28		
12 noon	29.87	82	0	ne.	29		
1 p.m.	29.86	75	.31	ne.	32		
2 p.m.	29.80	76	.38	ne.	38		
3 p.m.	29.79	74	.16	ne.	37		
4 p.m.	29.73	75	.05	ne.	39		
5 p.m.	29.69	76	T.	ne.	50		
6 p.m.	29.65	78	T.	ne.	54		
7 p.m.	29.64	78	0	ne.	50		

Wilmington, North Carolina.
Latitude 34° 14′ N. Longitude 77° 57′ W.
To the right of the line followed by the center of the cyclone, 135 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
13th							
1 a.m.	30.09	77	0	e.	5		
2 a.m.	30.08	76	0	e.	6		
3 a.m.	30.07	77	0	e.	5		
4 a.m.	30.06	77	0	e.	8		
5 a.m.	30.05	77	0	e.	9		
6 a.m.	30.03	77	0	e.	9		
7 a.m.	30.03	80	0	e.	11		
8 a.m.	30.03	81	0	e.	15	ci.	w.
9 a.m.	30.03	81	0	e.	16		
10 a.m.	30.03	82	T.	e.	16		
11 a.m.	30.03	82	0	e.	17	st. cu.	se.
12 noon	30.02	83	0	e.	17		
1 p.m.	30.01	81	0	e.	18		
2 p.m.	30.00	81	0	e.	16	st. cu.	e.
3 p.m.	29.98	81	0	e.	19		
4 p.m.	29.96	80	T.	e.	18	st. cu.	e.
5 p.m.	29.94	80	T.	e.	15		
6 p.m.	29.92	80	0	e.	17		
7 p.m.	29.91	78	T.	e.	16		
8 p.m.	29.90	78	01	e.	15	st. cu.	e.

Savannah, Georgia.

Latitude 32° 05′ N. Longitude 81° 05′ W.
To the left of the line followed by the center of the cyclone, 100 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
13th							
10 p.m.	29.72	75	0	nw.	33		
11 p.m.	29.71	76	0	nw.	32		
12 mid.	29.70	76	T.	nw.	33	Center	
14th						Passed	
1 a.m.	29.72	76	T.	nw.	31		
2 a.m.	29.72	76	T.	nw.	29		
3 a.m.	29.73	76	0	nw.	26		
4 a.m.	29.73	76	0	nw.	25		
5 a.m.	29.74	75	0	w.	22		
6 a.m.	29.76	75	0	w.	20		
7 a.m.	29.78	76	0	w.	22		
8 a.m.	29.79	76	0	w.	23	st. cu.	w.
9 a.m.	29.80	80	0	w.	27		
10 a.m.	29.81	82	0	w.	30		
11 a.m.	29.81	83	0	w.	27	a. cu.	w.
12 noon	29.81	84	0	w.	25	cu.	w.
1 p.m.	29.80	87	0	w.	25		
2 p.m.	29.80	88	0	w.	24		
3 p.m.	29.81	89	0	sw.	27		
4 p.m.	29.81	88	0	sw.	23		
5 p.m.	29.82	89	0	sw.	20		

Charleston, South Carolina.

Latitude 32° 47′ N. Longitude 79° 56′ W.
To the left of the line followed by the center of the cyclone, 25 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
13th							
10 p.m.	29.54	76	.03	ne.	39		
11 p.m.	29.47	74	.08	ne.	49		
12 mid.	29.40	75	.07	n.	49		
14th							
1 a.m.	29.28	74	.13	n.	48		
2 a.m.	29.12	73	.14	n.	54		
3 a.m.	29.05	72	.10	nw.	56		
4 a.m.	29.02	71	.20	nw.	52	Center	
5 a.m.	29.10	72	.18	w.	53	Passed	
6 a.m.	29.22	73	.06	w.	50		
7 a.m.	29.34	73	.06	sw.	43		
8 a.m.	29.40	73	.03	sw.	44	st.	sw.
9 a.m.	29.47	74	.14	sw.	45		
10 a.m.	29.55	74	.16	sw.	43		
11 a.m.	29.62	75	.06	sw.	39		
12 noon	29.68	75	.12	sw.	31		
1 p.m.	29.72	75	.28	sw.	33		
2 p.m.	29.74	79	.05	sw.	25		
3 p.m.	29.76	79	.10	s.	29		
4 p.m.	29.75	78	.07	s.	30		
5 p.m.	29.76	79	.04	s.	31		

Wilmington, North Carolina.

Latitude 34° 14′ N. Longitude 77° 57′ W.
To the right of the line followed by the center of the cyclone, 135 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction
13th							
10 p.m.	29.90	76	.03	e.	19		
11 p.m.	29.89	76	.05	e.	17		
12 mid.	29.88	77	.02	e.	21		
14th							
1 a.m.	29.88	77	0	e.	18		
2 a.m.	29.87	77	0	e.	20		
3 a.m.	29.86	77	0	e.	19		
4 a.m.	29.86	79	0	e.	20		
5 a.m.	29.87	79	0	e.	21	Center	
6 a.m.	29.88	73	.02	se.	17	Passed	
7 a.m.	29.90	73	.16	se.	18		
8 a.m.	29.91	74	.03	se.	18	nb.	se.
9 a.m.	29.93	76	.04	se.	17		
10 a.m.	29.94	77	.02	se.	19		
11 a.m.	29.95	77	.01	se.	17		
12 noon	29.96	76	.02	se.	16	nb.	se.
1 p.m.	29.97	76	.10	se.	18		
2 p.m.	29.98	76	.06	se.	17		
3 p.m.	29.98	76	.04	se.	18		
4 p.m.	29.99	77	.04	se.	19	nb.	se.
5 p.m.	30.00	77	.01	se.	19		

TABLE XIII

TROPICAL CYCLONE ON THE SOUTH ATLANTIC COAST, JULY 31-AUG. 1, 1916
75th Meridian Time

Savannah, Georgia.
Latitude 32° 05′ N. Longitude 81° 05′ W. To the left of the line followed by the center of the cyclone, 100 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
14th							
6 p.m.	29.82	85	0	sw.	15		
7 p.m.	29.85	80	0	sw.	14	a. st.	0
8 p.m.	29.86	80	.11	s.	15	cu.	s.
9 p.m.	29.88	80	T.	s.	19	st. cu.	s.
10 p.m.	29.89	80	0	s.	24		
11 p.m.	29.90	79	0	s.	26		
12 mid.	29.92	77	0	s.	22		
15th							
1 a.m.	29.93	78	0	s.	17		
2 a.m.	29.94	77	.01	s.	19		
3 a.m.	29.95	77	0	s.	21		
4 a.m.	29.96	78	0	s.	14		
5 a.m.	29.97	78	0	s.	14		
6 a.m.	29.99	78	0	s.	11		
7 a.m.	30.01	80	0	s.	11		
8 a.m.	30.03	82	0	s.	13	ci. cu.	w.
9 a.m.	30.04	82	0	s.	16	cu.	se.
10 a.m.	30.04	83	0	s.	19		
11 a.m.	30.05	84	0	s.	21		

Charleston, South Carolina.
Latitude 32° 47′ N. Longitude 79° 56′ W. To the left of the line followed by the center of the cyclone, 25 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
14th							
6 p.m.	29.79	78	.02	s.	32		
7 p.m.	29.80	79	.09	s.	33		
8 p.m.	29.84	80	.03	s.	35	cu.	sw.
9 p.m.	29.87	80	.02	s.	35	st.	s.
10 p.m.	29.89	80	T.	s.	31		
11 p.m.	29.92	79	.01	s.	32		
12 mid.	29.93	79	.04	s.	26		
15th							
1 a.m.	29.95	80	.01	s.	25		
2 a.m.	29.96	80	.06	s.	22		
3 a.m.	29.96	79	.34	s.	19		
4 a.m.	29.99	79	.21	s.	19		
5 a.m.	29.99	74	.21	s.	14		
6 a.m.	30.02	79	.01	s.	14		
7 a.m.	30.04	78	.20	s.	19		
8 a.m.	30.06	78	0	s.	21	ci. st.	w.
9 a.m.	30.10	78	0	s.	20	st.	s.
10 a.m.	30.11	80	0	se.	18		
11 a.m.	30.11	81	0	s.	20		

Wilmington, North Carolina.
Latitude 34° 14′ N. Longitude 77° 57′ W. To the right of the line followed by the center of the cyclone, 135 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction
14th							
6 p.m.	30.00	78	0	se.	18		
7 p.m.	30.01	78	0	se.	16		
8 p.m.	30.02	78	0	se.	17	st. cu.	s.
9 p.m.	30.04	78	0	se.	15		
10 p.m.	30.06	78	0	se.	16		
11 p.m.	30.07	78	0	se.	15		
12 mid.	30.08	78	0	se.	14		
15th							
1 a.m.	30.09	78	0	se.	14		
2 a.m.	30.09	78	0	s.	14		
3 a.m.	30.08	78	0	s.	13		
4 a.m.	30.09	77	0	s.	13		
5 a.m.	30.11	77	0	s.	11		
6 a.m.	30.12	77	0	s.	11		
7 a.m.	30.14	77	0	s.	11		
8 a.m.	30.16	78	0	se.	12	st. cu.	se.
9 a.m.	30.18	79	0	se.	13		
10 a.m.	30.20	79	0	se.	12		
11 a.m.	30.22	81	0	s.	14		

TABLE XIII-a

HEAVY PRECIPITATION IN SOUTH CAROLINA AND NORTH CAROLINA, JULY 15 TO 17, 1916, IN A DYING CYCLONE

75th Meridian Time

STATION	July 15th		July 16th		July 17th	
SOUTH CAROLINA	a. m.	p. m.	a. m.	p. m.	a. m.	p. m.
Georgetown		3.75				
Kemassee	5.53					
St. George	5.50					
Ferguson	7.52					
Kingstree	12.60					
Effingham	13.25					
Maysville (near)		4.18				
Florence		11.05				
Kershaw		5.73				
Blairs	4.25		.96		.37	
Catawba	6.60		.78			
Spartanburg		4.00		4.50		.50
White Oak		6.02				.09
Gaiston Shoal		3.20		6.42		.33
NORTH CAROLINA						
Hendersonville		2.38		9.92		.02
Blantyre		2.85		13.25		.12
Marion		7.83		3.69		1.14
Hickory		9.88		3.30		.02
Altapass		3.90		19.32		.05
Banners Elk		7.20		8.66		.77
Globe (near)		7.90		10.10		.38
Blowing Rock		9.85		6.50		0
North Wilkesboro		9.08		2.38		0
Transon		10.65		7.40		0
Jefferson		7.35		4.30		.08

Observations at 8 a.m. and (p.m.) about sunset.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

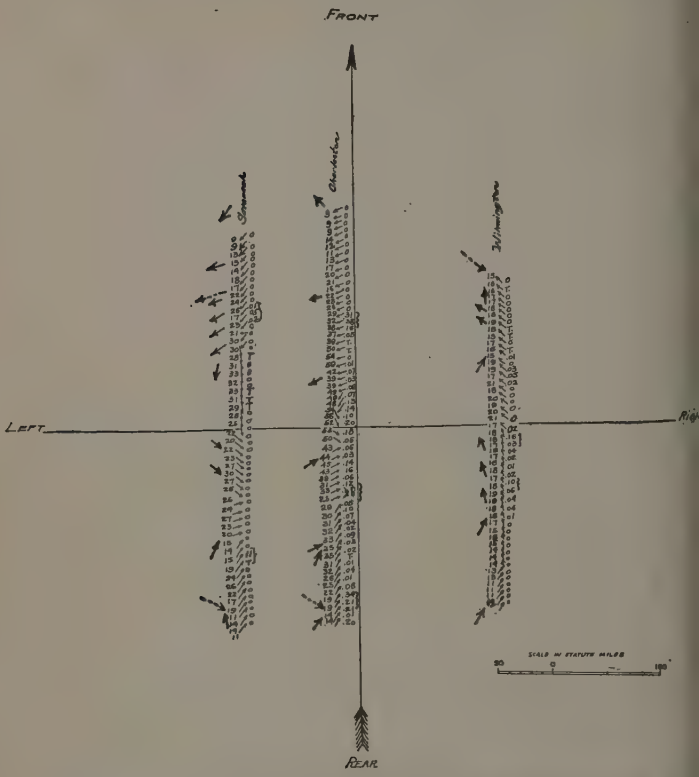


Figure 31. Records made during the passage of the tropical cyclone, July 12-16 1916. Intersection of cross lines represents the center of the cyclone. Points o small regular arrows rest on positions of stations at the time the records wer made. Figures on the left of the arrows are wind velocities in miles per hour figures on the right of the arrows are hourly precipitation measured to hundredth of an inch. Brackets show greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of the smaller cyclones which ceased to advanc on moving inland.

XIV

ropical Cyclone on the Middle Gulf Coast September 27-29, 1917

Detailed meteorological data recorded during the passage of ie tropical cyclone of September 27-29, 1917, (20), are shown Table XIV. This disturbance moved through the Yucatan hannel and thence northeastward over the Gulf of Mexico. 'hen approaching close to the mouth of the Mississippi River, ie cyclone changed its course rapidly from a northwestward rection to northeastward with a decided curve as shown in ath "N," Figure 2, which places it in a class by itself. The ourly wind direction and velocity and precipitation during the clone of September 27-29, 1917, are shown in Figure 32, for ew Orleans, La., Mobile, Ala., and Pensacola, Fla., first in the ght front quadrant and then in the left half of the cyclonic ea. The wind directions in the front show varying inclina- on towards the center; and in the left rear quadrant, they are ainly across the line along which the cyclonic center was dvancing.

The directions of the lower clouds differed somewhat from ie directions of the surface winds. Three observations of cirrus ouds in the front of the cyclone showed them moving from ft to right somewhat across the line of advance of the cyclone ut inclined in the same direction as that in which the cyclone as traveling. Cirrus clouds recorded at Pensacola, Fla., in ont of the cyclone, had a direction the same as that in which ie cyclone was traveling. One observation of cirrus in the rear oved from left to right across the line of advance and was mewhat opposed to the direction in which the cyclone was aveling.

The greater part of the precipitation occurred in the front the cyclonic area. The greatest precipitation intensity oc- rred at Pensacola, Fla., about two hours before the passage the storm center. There was an earlier period of heavy rain ell in front of the cyclonic area, occurring about 15 hours efore the passage of the storm center and about the time the

cyclone curved and commenced moving towards Pensacola. There was no heavy precipitation after the passage of the storm center. An area of high pressure appeared over the Plains region on the 27th, and the pressure was high generally west of the Mississippi Valley during the 28th and 29th. This influenced not only the direction of movement but also the winds and precipitation in this cyclone.

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 27 TO 29, 1917

ABLE XIV 90th Meridian Time

New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the left of the line followed by the center of the cyclone, 130 miles.								Burrwood, Louisiana. Latitude 28° 58′ N. Longitude 89° 23′ W. To the left of the line followed by the center of the cyclone, 60 miles.			
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction	Date and Hour	Pressure Inches (Sea Level)	Wind Direction	Wind Velocity Miles Per Hour
27th						ci. st.	sw.	27th			
a.m.	29.84	83	0	ne.	11	st. cu.	ne.	1 a.m.			24
noon	29.83	84	0	e.	13			2 a.m.			22
p.m.	29.82	84	0	e.	14	st. cu.	ne.	3 a.m.			21
p.m.	29.81	70	.50	se.	12			4 a.m.			19
p.m.	29.80	72	.03	ne.	8	a. st.	se.	5 a.m.			17
p.m.	29.79	75	0	ne.	10			6 a.m.			18
p.m.	29.78	75	0	ne.	11			7 a.m.			15
p.m.	29.78	75	0	ne.	11			8 a.m.	29.78	e.	17
p.m.	29.77	76	0	ne.	15	st. cu.	ne.	9 a.m.			16
p.m.	29.77	74	0	ne.	17			10 a.m.			16
p.m.	29.77	74	0	ne.	17			11 a.m.			21
p.m.	29.76	75	0	ne.	17			12 noon			26
p.m.	29.76	73	T.	ne.	18			1 p.m.			27
mid.	29.73	74	T.	ne.	18			2 p.m.			26
28th								3 p.m.			24
a.m.	29.70	72	.03	ne.	19			4 p.m.			21
a.m.	29.67	74	.01	ne.	18			5 p.m.			
a.m.	29.65	75	0	ne.	22			6 p.m.	29.63	se.	
a.m.	29.63	75	0	ne.	23	st. cu.	ne.	7 p.m.	29.61	se.	27
a.m.	29.63	75	0	ne.	23			8 p.m.	29.61	e.	32
a.m.	29.63	75	0	ne.	23			9 p.m.			35
a.m.	29.63	74	0	ne.	25	a. st.	n.	10 p.m.			37
a.m.	29.63	74	0	ne.	26	st.	ne.	11 p.m.	29.56	se.	41
a.m.	29.63	76	0	ne.	24	a. st.	?	12 mid.	29.54	se.	45
a.m.	29.63	79		n.	24	st. cu.	ne.	28th			
a.m.	29.63	79	0	ne.	25	st.	ne.	1 a.m.			46
noon	29.62	79	0	ne.	24			2 a.m.	29.42	e.	50
p.m.	29.61	78	0	n.	24	st. cu.	ne.	3 a.m.	29.30	e.	56
p.m.	29.61	79	0	n.	24			4 a.m.			51
30 pm	29.60	Center Passed						5 a.m.			60
p.m.	29.61	79	0	n.	21	st. cu.	n.	6 a.m.	29.13	ne.	72
p.m.	29.65	77	0	nw.	22			7 a.m.	29.11	ne.	64
p.m.	29.67	77	0	nw.	20			8 a.m.			56
p.m.	29.73	76	0	nw.	19			9 a.m.	29.14	ne.	51
p.m.	29.74	76	0	n.	14	st. cu.	n.	10 a.m.	29.24	n.	44

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 27 TO 29, 1917

TABLE XIV 90th Meridian Time

New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the left of the line followed by the center of the cyclone, 130 miles.								Burrwood, Louisiana. Latitude 28° 58′ N. Longitude 89° 23′ W. To the left of the line followed by the center of the cyclone, 60 miles.			
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds: Kind	Clouds: Direction	Date and Hour	Pressure Inches (Sea Level)	Wind Direction	Wind Velocity Miles Per Hour
28th								28th			
8 p.m.	29.77	76	0	nw.	15			11 a.m.			45
9 p.m.	29.80	76	0	nw.	13			12 noon	29.33	n.	55
10 p.m.	29.80	75	0	nw.	14			1 p.m.			50
11 p.m.	29.82	75	0	nw.	13			2 p.m.			47
12 mid.	29.83	75	0	nw.	14			3 p.m.			37
29th								4 p.m.	29.56	n.	37
1 a.m.	29.82	72	0	nw.	9			5 p.m.			32
2 a.m.	29.82	71	0	nw.	10			6 p.m.			31
3 a.m.	29.82	71	0	nw.	13			7 p.m.			30
4 a.m.	29.82	69	0	nw.	13			8 p.m.	29.71	nw.	31
5 a.m.	29.83	69	0	nw.	10			9 p.m.			27
6 a.m.	29.84	68	0	nw.	12	ci. st.	n.	10 p.m.			25
7 a.m.	29.84	68	0	nw.	12	ci. cu.	n.	11 p.m.			19
8 a.m.	29.89	69	0	nw.	12	a. cu.	n.	12 mid.			18
9 a.m.	29.90	71	0	nw.	12			29th			
10 a.m.	29.90	72	0	nw.	14			1 a.m.			17
11 a.m.	29.88	73	0	nw.	15			2 a.m.			19
12 noon	29.86	77	0	nw.	15			3 a.m.			17
1 p.m.	29.86	77	0	nw.	13			4 a.m.			16
2 p.m.	29.86	80	0	nw.	13			5 a.m.			15
3 p.m.	29.85	82	0	nw.	14			6 a.m.			18

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 27 TO 29, 1917

ABLE XIV 90th Meridian Time

Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the left of the line followed by the center of the cyclone, 60 miles.								Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the left of the line followed by the center of the cyclone, 12 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds	
						Kind	Direction							Kind	Direction
27th								27th						ci. cu.	s.
a.m.	29.92	73	0	e.	10			7 a.m.	29.91	75	.02	e.	22	cu.	s.
a.m.	29.93	73	0	e.	8	ci.	sw.	8 a.m.	29.91	76	.01	e.	18	st. cu.	s.
a.m.	29.92	74	0	e.	13	st.	se.	9 a.m.	29.91	79	.11	se.	23		
a.m.	29.92	76	0	e.	16			10 a.m.	29.91	78	.18	se.	22	cu.	s.
a.m.	29.93	77	T.	e.	13			11 a.m.	29.91	79	.09	se.	19	st.	s.
a.m.	29.92	78	T.	e.	10			12 noon	29.89	80	0	se.	17	st. cu.	se.
a.m.	29.91	81	0	e.	5	st.	se.	1 p.m.	29.86	80	0	se.	21	nb.	se.
noon	29.88	81	0	se.	7			2 p.m.	29.87	79	.01	se.	22		
p.m.	29.87	81	.21	s.	7	st.	s.	3 p.m.	29.88	73	.12	s.	24	nb.	s.
p.m.	29.86	75	0	sw.	12			4 p.m.	29.87	73	.19	s.	14		
p.m.	29.84	72	.35	sw.	10	st.	s.	5 p.m.	29.86	75	.01	se.	12		
p.m.	29.85	72	.31	s.	6			6 p.m.	29.86	74	.01	e.	8	st. cu.	s.
p.m.	29.85	72	T.	se.	6			7 p.m.	29.87	74	.01	e.	12	st.	s.
p.m.	29.87	72	T.	ne.	8			8 p.m.	29.88	73	.01	ne.	15		
p.m.	29.86	72	0	ne.	11	st.	ne.	9 p.m.	29.87	73	T.	e.	16		
p.m.	29.87	73	0	ne.	14			10 p.m.	29.85	73	0	ne.	16		
p.m.	29.87	73	0	ne.	13			11 p.m.	29.85	73	0	ne.	17		
p.m.	29.87	73	0	ne.	10			12 mid.	29.84	73	0	ne.	19		
p.m.	29.86	73	0	ne.	12			28th							
mid.	29.83	73	0	ne.	17			1 a.m.	29.82	72	T.	ne.	18		
28th								2 a.m.	29.79	71	T.	ne.	20		
a.m.	29.80	73	T.	ne.	13			3 a.m.	29.77	70	.46	ne.	25		
a.m.	29.78	73	.01	ne.	15			4 a.m.	29.76	70	.18	ne.	32		
a.m.	29.78	72	.09	ne.	15			5 a.m.	29.76	71	.43	ne.	27		
a.m.	29.78	71	.04	ne.	16			6 a.m.	29.76	72	.37	e.	22		
a.m.	29.77	71	.07	ne.	17			7 a.m.	29.75	72	.03	e.	28	nb.	se.
a.m.	29.74	71	.14	ne.	19			8 a.m.	29.74	73	.04	e.	31	nb.	se.
a.m.	29.73	71	.11	ne.	22	st.	e.	9 a.m.	29.68	74	.15	e.	39		
a.m.	29.72	70	.09	ne.	29			10 a.m.	29.60	75	.11	e.	47	nb.	e.
a.m.	29.69	70	.22	ne.	35			11 a.m.	29.53	74	.20	e.	53		
a.m.	29.63	69	.25	ne.	39	st.	ne.	12 noon	29.43	74	.20	e.	64	nb.	e.
a.m.	29.55	69	.38	ne.	38			1 p.m.	29.33	74	.11	e.	73	nb.	se.
noon	29.45	69	.44	ne.	47			2 p.m.	29.19	74	.08	e.	79		
p.m.	29.37	69	.52	ne.	51	st.	ne.	3 p.m.	29.09	74	.21	e.	88	nb.	se.
p.m.	29.22	70	.42	ne.	71			4 p.m.	28.86	73	.27	se.	95		
p.m.	29.18	70	.14	n.	87	st.	n.	5 p.m.	28.73	72	.75	se.	96		

TROPICAL CYCLONE ON THE MIDDLE GULF COAST, SEPTEMBER 27 TO 29, 1917

TABLE XIV 90th Meridian Time

Mobile, Alabama. Latitude 30° 41′ N. Longitude 88° 02′ W. To the left of the line followed by the center of the cyclone, 60 miles.								Pensacola, Florida. Latitude 30° 25′ N. Longitude 87° 13′ W. To the left of the line followed by the center of the cyclone, 12 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
28th								28th							
4 p.m.	29.17	69	.16	n.	86			6 p.m.	28.55	70	.88	e.	95		
4:15 pm	29.16	C	ent	er	Pass	ed		6:20 pm	28.51	C	ent	er P	asse	d	
5 p.m.	29.23	69	.09	nw.	85			7 p.m.	28.56	67	.58	ne.	84	nb.	ne.
6 p.m.	29.29	68	.09	nw.	75			8 p.m.	28.87	66	.80	n.	87		
7 p.m.	29.36	68	.08	nw.	68	st.	nw.	9 p.m.	29.01	66	.40	nw.	83		
8 p.m.	29.46	67	.13	nw.	56			10 p.m.	29.21	66	.11	nw.	78		
9 p.m.	29.53	67	.15	nw.	48			11 p.m.	29.32	65	T.	nw.	68		
10 p.m.	29.56	67	.03	nw.	41			12 mid.	29.34	64	T.	nw.	62		
11 p.m.	29.59	67	.01	nw.	37			29th							
12 mid.	29.60	67	.03	nw.	32			1 a.m.	29.45	65	.01	nw.	59		
29th								2 a.m.	29.48	65	.02	nw.	59		
1 a.m.	29.63	67	.08	nw.	28			3 a.m.	29.50	65	.04	nw.	52		
2 a.m.	29.65	67	.06	nw.	26			4 a.m.	29.53	66	.02	nw.	47		
3 a.m.	29.67	67	.08	nw.	25			5 a.m.	29.56	66	T.	w.	47		
4 a.m.	29.67	67	.06	nw.	23			6 a.m.	29.61	66	.02	nw.	40		
5 a.m.	29.67	67	.02	nw.	22			7 a.m.	29.63	68	T.	nw.	40	st. cu.	nw.
6 a.m.	29.67	67	T.	nw.	22			8 a.m.	29.66	68	T.	nw.	39		
7 a.m.	29.70	68	T.	nw.	23	st.	nw.	9 a.m.	29.68	70	0	nw.	38		
8 a.m.	29.70	68	T.	nw.	24			10 a.m.	29.70	70	T.	nw.	38		
9 a.m.	29.70	69	T.	nw.	22			11 a.m.	29.71	70	0	nw.	37		
								12 noon	29.69	73	0	nw.	31		

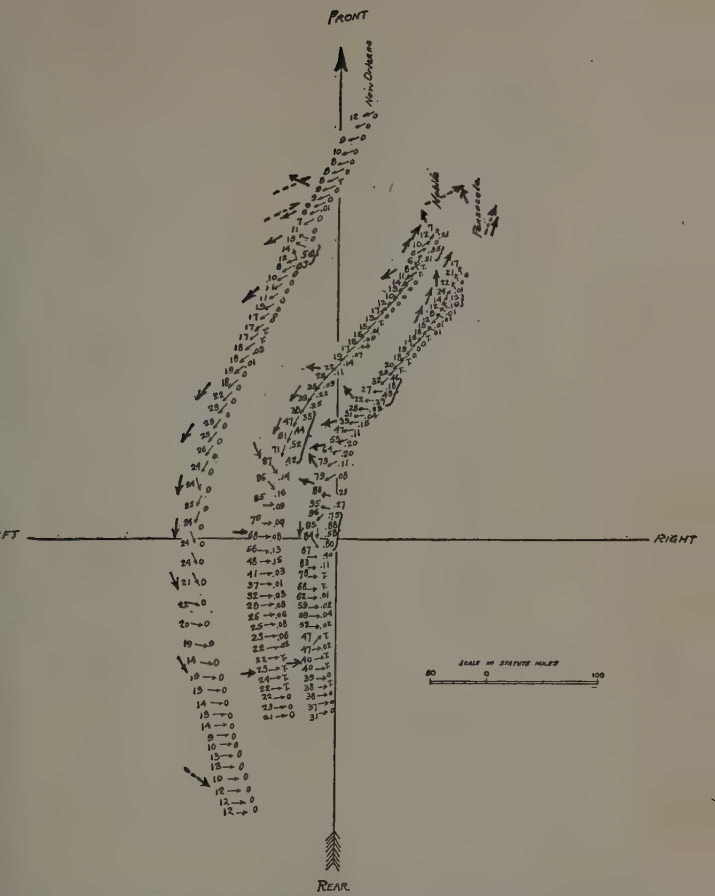


Figure 32. Records made during the passage of the tropical cyclone, September 27-29, 1917. Intersection of cross lines represents the center of the cyclone. Points of small arrows rest on the positions of stations at the time the records were made; figures on the left of the arrows are wind velocities in miles per hour; figures on the right of the arrows are the hourly precipitation measured to hundredths of an inch. Brackets show greatest hourly precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of smaller cyclones which advanced on an unusually sharp curve,

XV

Tropical Cyclone on West Coast of Louisiana August 4-6, 1918

A small cyclone of great intensity near the center passed through the Yucatan Channel during the night of August 4-5, 1918, (30), and its center moved inland on the Louisiana Coast to the east of Sabine Pass about noon, August 6, 1918, as shown on path "O," Figure 2. This storm was of great intensity over an area fifty miles wide to the right of the path of the center. It traveled with unusual speed and diminished in intensity soon after moving inland. New Orleans, La., was the nearest station on the right of the path of this cyclone, Port Arthur, and Houston, Texas, were in the left half of the cyclonic area. The hourly wind directions and velocities and precipitation during the passage of this cyclone are charted in Figure 33.

'ROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

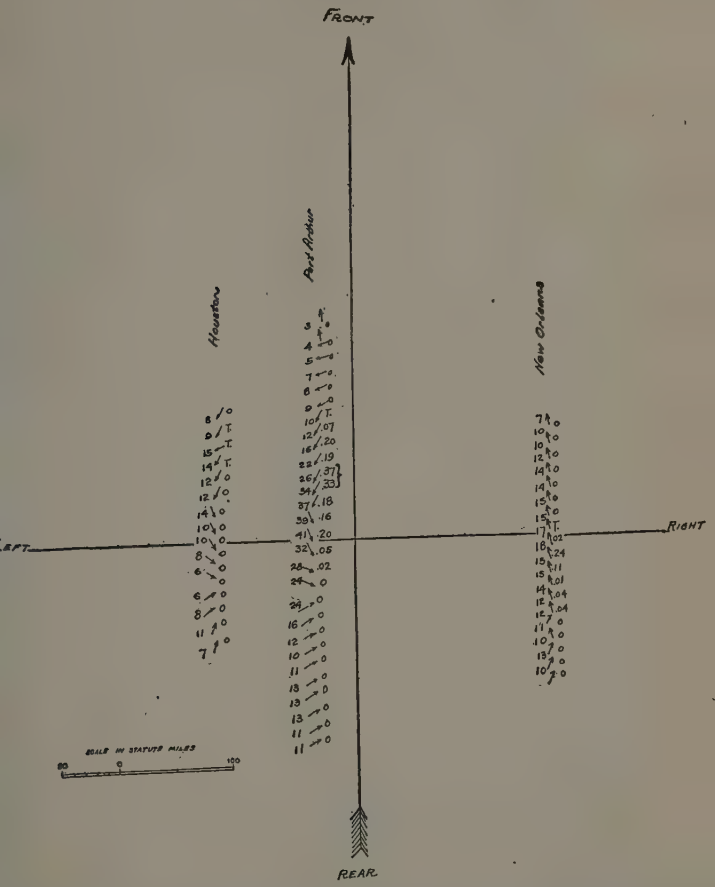


Figure 33. Records made during the passage of the tropical cyclone, August 5-6, 1918. Intersection of cross lines represents the center of the cyclone. Points of small regular arrows rest on positions of stations at the time the records were made; figures to the left of the arrows are wind velocities in miles per hour; figures to the right of the arrows are hourly precipitation measured to hundredths of an inch. Brackets show the greatest hourly precipitation intensity.

This was a very small cyclone; the area with storm winds was less than 100 miles in diameter.

XVI

Tropical Cyclone Which Moved Westward in the Gulf to the Texas Coast September 8-19, 1919

The tropical cyclone of September 8-19, 1919, followed an unusual course through the Florida Straits, thence westward across the Gulf of Mexico and moved inland about 45 miles to the southward of Corpus Christi, Texas. The automatic records at both Key West, Fla., and Corpus Christi, Texas, the stations near the center, failed during the passage of the cyclone; the records though incomplete are of special interest and are shown in Table XV. Weightman (37) has made a very thorough study of the upper air movements in connection with this cyclone and has shown that there was an east to west current during September 5th to 14th, 1919, over the Mexican Gulf coastal region and this determined the direction in which the cyclone traveled.

According to Weightman the easterly current was in evidence up to the 5 km. level at Groesbeck, Houston (Ellington Field) and San Antonio (Kelly Field), Texas, from the 1st of the month until the storm moved inland on the 14th. To the eastward at Leesburg, Ga., the current from the east was fully established and continued so until the 12th, when west to north winds were encountered between 4 and 6 km. elevation. These winds were of temporary duration for on the 15th the winds were ENE. to ESE. up to 11 km., and it was not until the 16th that they changed to steady westerly.

Clouds recorded on the Texas Coast, both at Galveston and Corpus Christi, show cirrus and also lower clouds moving from southeast on the 13th. This cyclone while in the Florida Straits encountered upper air currents moving towards the west. For a few days the cyclone remained nearly stationary or moved very slowly through the Florida Straits and the East Gulf, taking three days, from 8 p. m. of the 9th to 8 p. m. of the 12th, in traveling from the vicinity of Key West, Fla., to a point in the middle Gulf south of the mouth of the Mississippi River, a distance of 500 miles, at the rate of only about 7 miles per hour. Such a slow movement of a cyclone in these latitudes

s out of the ordinary and would not likely occur unless the dvance of the cyclone is opposed by an air current from a lifferent direction to that in which the cyclone has been travel-ng. In this case we find the cyclone moving very slowly towards he westnorthwest from the 9th to the 13th, with a tendency o recurve, but the easterly current forced the cyclone slowly vestward preventing the recurve. The easterly current became he dominant factor on the 13th and the cyclone took up a ourse and traveled nearly due west during the 13th and 14th, vith increasing speed, its velocity now being 12 to 14 miles er hour. The course followed by this cyclone is shown in path E," Figure 2.

Tropical Cyclone Which Moved Through the Florida Straits and Thence Westward Over the Gulf of Mexico, September 9 to 15, 1919

TABLE XV

Key West, Florida. Latitude 24° 33′ N. Longitude 81° 48′ W. To the right of the line followed by the center of the cyclone, 20 miles. 75th Meridian Time								Corpus Christi, Texas. Latitude 27° 49′ N. Longitude 97° 25′ W. To the right of the line followed by the center of the cyclone, 45 miles. 90th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds	
						Kind	Direction							Kind	Direction
9th								13th							
1 a.m.	29.69	80	0	ne.	24			3 p.m.	29.73	92	0	n.	20		
2 a.m.	29.66	81	0	n.	26			4 p.m.	29.70	90	0	n.	25		
3 a.m.	29.65	81	T.	n.	28			5 p.m.	29.69	90	0	n.	29		
4 a.m.	29.64	74	.28	ne.	25			6 p.m.	29.68	88	0	n.	27		
5 a.m.	29.62	79	.01	ne.	28			7 p.m.	29.67	87	0	n.	24	ci.	se.
6 a.m.	29.60	79	0	ne.	28			8 p.m.	29.68	86	0	n.	19	a. cu.	ne.
7 a.m.	29.61	80	0	ne.	30			9 p.m.	29.69	85	0	n.	20		
8 a.m.	29.61	79	T.	ne.	33	ci. st.	n.	10 p.m.	29.68	85	0	n.	24		
9 a.m.	29.58	80	T.	ne.	32	cu.	n.	11 p.m.	29.65	84	0	n.	26		
10 a.m.	29.56	78	.04	ne.	35			12 mid.	29.62	82	0	n.	29		
11 a.m.	29.54	76	.10	ne.	37	nb.	ne.	14th							
12 noon	29.50	79	.03	ne.	31	st. cu.	ne.	1 a.m.	29.60	81	0	n.	30		
1 p.m.	29.46	76	.07	ne.	36	nb.	ne.	2 a.m.	29.57	80	.09	n.	32		
2 p.m.	29.40	77	.08	ne.	37			3 a.m.	29.56	73	.04				
3 p.m.	29.31	74	.23	ne.	45	nb.	ne.	4 a.m.	29.52	74	.05	nw.	36		
4 p.m.	29.27	75	.30	ne.	46			5 a.m.	29.49	74	.16	nw.	39		
5 p.m.	29.22	74	.18	ne.	49			6 a.m.	29.44	74	.18	n.	39		
6 p.m.	29.13	74	.34	ne.	54			7 a.m.	29.37	74	.10	nw.	42	st.	n.
7 p.m.	29.08	74	.61	ne.	53			8 a.m.	29.29	74	.11	nw.	46		
8 p.m.	29.05	74	.67	ne.				9 a.m.	29.15	74	.16	n.	40		
9 p.m.	28.99	74	.67	ne.				10 a.m.	29.12	75		n.	46		
10 p.m.	28.97	74	.75	ne.				11 a.m.	29.00	76		n.	70		
11 p.m.	28.93	74	.52	ne.				12 noon	28.91	77		ne.	72	nb.	ne.
12 mid.	28.81	75	.57	e.				1 p.m.	28.68	75					
10th								2 p.m.	28.66	75					
1 a.m.	28.90	75	.83	e.				3 p.m.	28.65	75				Center	
2 a.m.	28.96	75	.65	e.				4 p.m.	28.76	76				Passed	
3 a.m.	29.02	75	.54	e.				5 p.m.	28.80	76					
4 a.m.	29.07	74	.86	e.		Center		6 p.m.	28.96	76					
5 a.m.	29.13	75		se.		Passed		7 p.m.	29.08	75				nb.	e.
6 a.m.	29.20	74		se.				8 p.m.	29.20	73					
7 a.m.	29.26	74		se.				9 p.m.	29.32	72					
8 a.m.	29.35	74		se.		nb.	se.	10 p.m.	29.42	73					
9 a.m.	29.39	74		se.				11 p.m.	29.48	74					

ROPICAL CYCLONE WHICH MOVED THROUGH THE FLORIDA STRAITS AND THENCE WESTWARD OVER THE GULF OF MEXICO, SEPTEMBER 9 TO 15, 1919

ABLE XV

Key West, Florida. Latitude 24° 33′ N. Longitude 81° 48′ W. To the right of the line followed by the center of the cyclone, 20 miles. 75th Meridian Time									Corpus Christi, Texas. Latitude 27° 49′ N. Longitude 97° 25′ W. To the right of the line followed by the center of the cyclone, 45 miles. 90th Meridian Time								
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
10th								14th							
a.m.	29.44	75		se.				12 mid.	29.58	75					
a.m.	29.46	78		se.				15th							
noon	29.50	78		se.				1 a.m.	29.66	77					
p.m.	29.53	79		se.		nb.	se.	2 a.m.	29.64						
p.m.	29.52	77		se.				3 a.m.	29.66						
p.m.	29.56	77		s.		nb.	s.	4 a.m.	29.72						
p.m.	29.57	76						5 a.m.	29.77						
p.m.	29.59	78						6 a.m.	29.79	80					
p.m.	29.61	79						7 a.m.	29.81	81				st.	se.
p.m.	29.62	80				a. st. cu.	? s.	8 a.m.	29.81	81					
p.m.	29.64	81						9 a.m.	29.81	81					
p.m.	29.66	81						10 a.m.	29.82	81					
p.m.	29.68	81						11 a.m.	29.82	82					
p.m.	29.70	80						12 noon	29.84	82				ci. cu. st. cu.	e. se.
mid.	29.72	80						1 p.m.	29.86						
								2 p.m.	29.89						

TROPICAL CYCLONE WHICH MOVED THROUGH THE FLORIDA STRAITS AND THENCE WESTWARD OVER THE GULF OF MEXICO, SEPTEMBER 9 TO 15, 1919

TABLE XV

Miami, Florida. Latitude 25° 48′ N. Longitude 80° 12′ W. To the right of the line followed by the center of the cyclone, 90 miles. 75th Meridian Time								Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 158 miles. 90th Meridian Time								New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 200 miles. 90th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds	
						Kind	Direction							Kind	Direction							Kind	Direction
8th								13th								12th							
11 p.m.	29.76	81	0	ne.	31			7 a.m.	29.79	73	0	n.	26	ci. st.	?	12 noon	29.77	87	0	e.	22	ci. st.	sw.
12 mid.	29.75	82	0	ne.	33			8 a.m.	29.79	74	0	n.	27	a. cu.	?	1 p.m.	29.76	88	0	e.	21	cu.	se.
9th								9 a.m.	29.79	75	0	n.	25			2 p.m.	29.74	87	0	e.	20	ci. st.	sw.
1 a.m.	29.73	81	0	ne.	34			10 a.m.	29.78	77	0	n.	24	ci. st.	se.	3 p.m.	29.73	86	0	e.	20	cu.	e.
2 a.m.	29.71	81	0	ne.	36			11 a.m.	29.77	81	0	n.	22	a. cu.	ne.	4 p.m.	29.72	84	0	e.	19	ci. st.	sw.
3 a.m.	29.73	78	.02	e.	35			12 noon	29.75	82	0	n.	21	a. cu.	ne.	5 p.m.	29.71	80	T.	se.	16	st. cu.	se.
4 a.m.	29.70	74	.13	e.	36			1 p.m.	29.73	84	0	n.	21	st. cu.	ne.	6 p.m.	29.73	78	T.	ne.	11	ci. st.	e.
5 a.m.	29.72	76	.02	e.	31									ci. st.	se.	7 p.m.	29.75	75	T.	ne.	13	st. cu.	ne.
6 a.m.	29.72	77	.01	e.	36			2 p.m.	29.71	86	0	ne.	24	a. cu.	e.	8 p.m.	29.75	78	T.	ne.	12		
7 a.m.	29.73	76	.04	e.	35	st. cu.	e.	3 p.m.	29.70	86	0	ne.	26	st. cu.	ne.	9 p.m.	29.76	78	0	ne.	12	a. st.	sw.
8 a.m.	29.73	78	T.	e.	37			4 p.m.	29.68	85	0	ne.	28	a. cu.	ne.	10 p.m.	29.76	78	0	ne.	12		
9 a.m.	29.74	78	T.	e.	40			5 p.m.	29.67	83	0	ne.	28	st. cu.	ne.	11 p.m.	29.76	77	0	ne.	15		
10 a.m.	29.74	77	0	e.	39			6 p.m.	29.67	83	0	ne.	23			12 mid.	29.75	77	0	ne.	14		
11 a.m.	29.74	79	0	e.	38			7 p.m.	29.68	81	0	ne.	22	st. cu.	ne.	13th							
12 noon	29.74	80	0	e.	32	nb.	e.	8 p.m.	29.68	79	T.	ne.	31			1 a.m.	29.74	77	0	ne.	15		
1 p.m.	29.72	79	T.	e.	33			9 p.m.	29.67	79	0	ne.	33			2 a.m.	29.72	77	0	ne.	15		
								10 p.m.	29.68	79	0	ne.	28										

TABLE XV

Miami, Florida.

Latitude 25° 48′ N. Longitude 80° 12′ W. To the right of the line followed by the center of the cyclone, 90 miles.

75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds	
						Kind	Direction
9th							
2 p.m.	29.70	79	T.	e.	34		
3 p.m.	29.71	77	.02	e.	40		
4 p.m.	29.70	78	.01	e.	35		
5 p.m.	29.68	79	.01	e.	35		
6 p.m.	29.70	79	.02	e.	35		
7 p.m.	29.71	76	.05	e.	33	nb.	e.
8 p.m.	29.71	80	T.	e.	34	Center	
9 p.m.	29.72	81	.01	e.	35	Passed	
10 p.m.	29.73	79	T.	e.	33		
11 p.m.	29.73	78	.02	se.	30		
12 mid.	29.74	79	T.	se.	27		
10th							
1 a.m.	29.74	79	0	se.	27		
2 a.m.	29.76	79	T.	e.	26		
3 a.m.	29.74	76	.02	se.	26		
4 a.m.	29.73	78	T.	se.	24		
5 a.m.	29.74	78	0	e.	24		

Galveston, Texas.

Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 158 miles.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds	
						Kind	Direction
13th							
11 p.m.	29.66	80	0	ne.	25		
12 mid.	29.63	80	0	ne.	29		
14th							
1 a.m.	29.62	80	T.	ne.	35		
2 a.m.	29.61	80	T.	ne.	35		
3 a.m.	29.61	79	.16	ne.	39		
4 a.m.	29.61	78	.46	ne.	39		
5 a.m.	29.61	81	T.	ne.	38		
6 a.m.	29.61	77	.18	e.	40		
7 a.m.	29.60	82	.02	e.	42	st. cu.	e.
8 a.m.	29.61	82	0	e.	44	Center	
9 a.m.	29.64	78	0	e.	42	Passed	
10 a.m.	29.66	80	.26	e.	42		
11 a.m.	29.67	81	.01	e.	42	st. cu.	e.
12 noon	29.67	81	.01	e.	37		
1 p.m.	29.67	82	0	e.	40	st. cu.	se.
2 p.m.	29.67	82	0	se.	39		

New Orleans, Louisiana.

Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 200 miles.

90th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds	
						Kind	Direction
13th							
3 a.m.	29.73	77	0	ne.	14		
4 a.m.	29.73	77	0	ne.	14		
5 a.m.	29.74	77	0	ne.	14		
6 a.m.	29.74	79	.23	e.	17		
7 a.m.	29.74	75	.08	ne.	18	st.	e.
8 a.m.	29.75	77	.02	e.	15	st. cu.	e.
9 a.m.	29.75	78	.04	e.	17		
10 a.m.	29.75	79	.09	e.	21	st.	e.
11 a.m.	29.78	81	.10	e.	21	st. cu.	e.
12 noon	29.77	83	.04	e.	27		
1 p.m.	29.77	84	.01	e.	27	st. cu.	e.
2 p.m.	29.76	80	.21	e.	15		
3 p.m.	29.76	80	.02	e.	19	nb.	e.
4 p.m.	29.77	75	.14	e.	21		
5 p.m.	29.78	75	.17	e.	18	st. cu.	se.
6 p.m.	29.79	80	.01	e.	20		
7 p.m.	29.80	80	T.	e.	22	st. cu.	e.

TROPICAL CYCLONE WHICH MOVED THROUGH THE FLORIDA STRAITS AND THENCE WESTWARD OVER THE GULF OF MEXICO.
SEPTEMBER 9 TO 15, 1919

TABLE XV

Miami, Florida. Latitude 25° 48′ N. Longitude 80° 12′ W. To the right of the line followed by the center of the cyclone, 90 miles. 75th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds Kind	Clouds Direction
10th							
6 a.m.	29.74	78	0	e.	28		
7 a.m.	29.75	79	0	e.	27		
8 a.m.	29.78	79	T.	e.	24	nb.	e.
9 a.m.	29.79	79	T.	e.	31		
10 a.m.	29.79	80	0	e.	25		
11 a.m.	29.78	80	0	se.	23		
12 noon	29.78	81	0	se.	24	st. cu. cu.	se. se.
1 p.m.	29.78	81	0	se.	25		
2 p.m.	29.76	81	0	se.	25		
3 p.m.	29.76	81	0	se.	25		
4 p.m.	29.76	81	0	se.	22		
5 p.m.	29.76	82	0	se.	22		
6 p.m.	29.77	81	0	se.	21		
7 p.m.	29.78	81	0	se.	20		
8 p.m.	29.79	81	0	se.	19	st. cu.	se.
9 p.m.	29.80	81	0	se.	19		

Galveston, Texas. Latitude 29° 18′ N. Longitude 94° 50′ W. To the right of the line followed by the center of the cyclone, 158 miles. 90th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds Kind	Clouds Direction
14th							
3 p.m.	29.67	83	0	se.	37		
4 p.m.	29.69	82	0	se.	37		
5 p.m.	29.71	82	T.	se.	36		
6 p.m.	29.72	82	.03	se.	37		
7 p.m.	29.74	81	.22	se.	36	st. cu.	se.
8 p.m.	29.78	79	.30	se.	35		
9 p.m.	29.80	77	.16	se.	37		
10 p.m.	29.82	81	T.	se.	35		
11 p.m.	29.84	81	0	se.	38		
12 mid.	29.85	81	0	se.	35		
15th							
1 a.m.	29.87	81	0	se.	31		
2 a.m.	29.87	81	0	se.	30		
3 a.m.	29.88	81	0	se.	30		
4 a.m.	29.89	81	0	se.	27		
5 a.m.	29.90	81	0	se.	23		

New Orleans, Louisiana. Latitude 29° 58′ N. Longitude 90° 04′ W. To the right of the line followed by the center of the cyclone, 200 miles. 90th Meridian Time							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	Clouds Kind	Clouds Direction
13th							
8 p.m.	29.81	80	T.	e.	22		
9 p.m.	29.82	80	.01	e.	20	st. cu.	se.
10 p.m.	29.83	81	0	e.	19		
11 p.m.	29.84	81	.01	se.	17		
12 mid.	29.86	81	0	se.	16		
14th							
1 a.m.	29.86	79	0	se.	15		
2 a.m.	29.86	77	0	se.	18		
3 a.m.	29.87	77	0	se.	16		
4 a.m.	29.87	78	0	se.	16		
5 a.m.	29.89	79	0	se.	16		
6 a.m.	29.90	79	0	se.	13		
7 a.m.	29.90	80	0	se.	14	ci. st. st. cu.	w. se.
8 a.m.	29.92	81	0	se.	17		
9 a.m.	29.94	81	0	se.	17		
10 a.m.	29.95	84	0	se.	17	ci. st. st. cu.	w. se.

XVII

Tropical Cyclone on the Texas Coast June 21-22, 1921

Detailed meteorological data recorded during the passage of e tropical cyclone of June 21-22, 1921, (31), are shown in able XVI. This cyclone was first noted in the Caribbean Sea ear Swan Island June 16th; it followed an unusual course across e Yucatan Peninsula into the Bay of Campeche thence north- ard over the Gulf of Mexico, slowly curving towards the east d its center moved inland over Matagorda Bay, Texas, aveling in a direction a little east of north as shown on path ," Figure 2. The hourly wind directions and velocities and ecipitation for Galveston and Houston, Texas, in the right lf and Corpus Christi, Texas, first in the right and then in the ft half of the cyclonic area are charted in Figure 34. The nds in the right rear quadrant were in the same general direc- on as that in which the cyclone was traveling. In the right ont quadrant the inclination of the winds towards the center minished considerably seven to eight hours before the passage the center. In the left front quadrant the winds do not show inclination towards the center.

The directions of the lower clouds in this cyclone were in ain the same as the surface winds. There is only one observa- on of cirrus and that well in the rear of the left rear quadrant th a direction across the line of advance of the cyclone.

The greatest hourly precipitation intensity was well in ad- nce of the cyclonic center. At Corpus Christi, Texas, it curred 18 hours before the passage of the cyclonic center when at station was in the right front quadrant of the cyclonic area. ly .02 of an inch of precipitation occurred at Corpus Christi ter the passage of the center.

At Houston, Texas, the total precipitation during the passage the cyclone was 3.22 inches, and 2.77 inches of this was re- rded in three hours commencing when the cyclonic center as 150 miles distant in space and 11 hours in time and ending nen the storm center was 110 miles distant in space and eight urs in time. This heavy precipitation was 75 miles to the

right of the line along which the cyclonic center was advancing at that time. At Galveston, Texas, at that time 110 miles to the right of the line along which the cyclonic center was advancing, the greatest hourly precipitation intensity was .41 inch in one hour when the center was 85 miles distant in space and seven hours before that station passed into the rear half of the cyclonic area. Precipitation ceased at Houston with the passage of the center and there was only .05 of an inch at Galveston after that station passed into the rear half of the cyclonic area.

In connection with the unusual course followed by the cyclone which appeared in the Caribbean Sea June 16th and reached the Texas Coast June 22, 1921, it is of interest and importance to note the movement of cirrus clouds recorded at New Orleans a few days previous to the first appearance of this cyclone. June 11th, cirro-stratus clouds were recorded from the north during most of the afternoon; June 12th, cirrus clouds prevailed throughout the day moving from the northwest, and cirrus clouds were recorded on the morning of the 13th from the northwest. The movement of the upper air current as shown by the clouds observed at New Orleans a few days previous to the appearance of the hurricane in the Caribbean Sea is of interest in connection with the unusual course followed by this cyclone during the first few days of its existence.

TABLE XVI

Corpus Christi, Texas.
Latitude 27° 49′ N. Longitude 97° 25′ W.
To the left of the line followed by the center of the cyclone, 45 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
21st							
7 a.m.	29.84	79	0	n.	12	st. cu.	e.
8 a.m.	29.85	78	T.	n.	16	st.	ne.
9 a.m.	29.86	76	.37	n.	17		
10 a.m.	29.88	76	.22	ne.	23		
11 a.m.	29.89	75	.07	ne.	23		
12 noon	29.89	73	.45	e.	26		
1 p.m.	29.89	74	.22	ne.	26		
2 p.m.	29.88	75	.15	ne.	25		
3 p.m.	29.87	75	.02	ne.	28		
4 p.m.	29.86	75	T.	ne.	37		
5 p.m.	29.85	75	.03	ne.	33	nb.	
6 p.m.	29.83	75	.04	ne.	36		ne.
7 p.m.	29.82	75	.02	ne.	36	nb.	
8 p.m.	29.82	75	.07	ne.	33		ne.
9 p.m.	29.82	74	.08	ne.	33		
10 p.m.	29.82	74	.04	ne.	31		
11 p.m.	29.80	76	.02	ne.	29		
12 mid.	29.78	75	.01	ne.	33		
22d							
1 a.m.	29.75	73	.08	ne.	34		
2 a.m.	29.70	72		ne.	41		
3 a.m.	29.66	72		ne.	46		

Houston, Texas.
Latitude 29° 47′ N. Longitude 95° 24′ W.
To the right of the line followed by the center of the cyclone, 35 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
22d							
1 a.m.	29.91	75	0	ne.	11		
2 a.m.	29.87	75	T.	ne.	11		
3 a.m.	29.86	74	.06	ne.	13		
4 a.m.	29.85	74	.15	ne.	13		
5 a.m.	29.84	74	T.	ne.	16		
6 a.m.	29.83	74	.02	ne.	17		
7 a.m.	29.78	74	1.04	ne.	23	nb.	e.
8 a.m.	29.76	73	.27	ne.	23	st.	e.
9 a.m.	29.75	73	1.46	ne.	21	st.	e.
10 a.m.	29.73	78	.03	e.	23	st.	e.
11 a.m.	29.67	76	.01	se.	28	st.	e.
12 noon	29.63	78	.04	se.	32	st.	e.
1 p.m.	29.59	77	.01	se.	44	st.	e.
2 p.m.	29.53	76	T.	se.	38	st.	se.
3 p.m.	29.51	73	0	se.	44	nb.	se.
4 p.m.	29.46	73	0	se.	47		
5 p.m.	29.37	71	.01	se.	49		
5:40 pm	29.37	Center Passed					
6 p.m.	29.38	69	.03	se.	41		
7 p.m.	29.48	69	T.	se.	37	st.	se.
8 p.m.	29.53	68	0	s.	36		
9 p.m.	29.58	68	0	s.	28		

Galveston, Texas.
Latitude 29° 18′ N. Longitude 94° 50′ W.
To the right of the line followed by the center of the cyclone, 90 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
21st							
11 p.m.	29.91	80	0	e.	18		
12 mid.	29.90	80	0	ne.	21		
22d							
1 a.m.	29.88	80	T.	e.	26		
2 a.m.	29.87	80	.02	e.	26		
3 a.m.	29.85	80	T.	e.	26		
4 a.m.	29.83	80	T.	ne.	28		
5 a.m.	29.81	79	.01	ne.	30		
6 a.m.	29.78	78	.02	e.	32		
7 a.m.	29.75	76	.12	ne.	40	st. cu.	e.
8 a.m.	29.73	77	.12	e.	41		
9 a.m.	29.72	79	.41	se.	44	a. st. st. cu.	? se.
10 a.m.	29.71	80	.03	se.	40	a. st. st. cu.	? e.
11 a.m.	29.70	78	.02	se.	43	st. cu.	se.
12 noon	29.68	79	.02	se.	44	st. cu.	se.
1 p.m.	29.66	79	T.	se.	46	st. cu.	se.
2 p.m.	29.65	78	T.	se.	47	st. cu.	se.
3 p.m.	29.64	78	T.	se.	52	st. cu.	se.
3:15 pm	29.63	Center Passed					
4 p.m.	29.64	78	T.	se.	52		
5 p.m.	29.65	77	T.	se.	44		

TABLE XVI — TROPICAL CYCLONE ON THE WEST GULF COAST, JUNE 21 TO 23, 1921 — 90th Meridian Time

Corpus Christi, Texas.
Latitude 27° 49′ N. Longitude 97° 25′ W.
To the left of the line followed by the center of the cyclone, 45 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
22d							
4 a.m.	29.65	70	(a)	n.	42		
5 a.m.	29.64	68	.48	n.	42		
6 a.m.	29.62	67		ne.	58	Center	P's
7 a.m.	29.60	68		n.	40	nb.	n.
8 a.m.	29.60	70	.01	n.	34		
9 a.m.	29.65	70	.01	nw.	25		
10 a.m.	29.69	71	T.	nw.	23	nb.	nw.
11 a.m.	29.72	74	T.	w.	25	st. cu.	nw.
12 noon	29.76	77	0	nw.	26	st. cu.	nw.
1 p.m.	29.79	79	0	nw.	22	st. cu.	nw.
2 p.m.	29.79	80	0	nw.	16	st. cu.	nw.
3 p.m.	29.78	81	0	nw.	19	ci.	e.
4 p.m.	29.78	82	0	nw.	16	st. cu.	nw.
5 p.m.	29.78	83	0	nw.	10		
6 p.m.	29.78	84	0	n.	7		
7 p.m.	29.78	84	0	n.	1	ci.	w.
8 p.m.	29.78	80	0	s.	5		
9 p.m.	29.79	78	0	ne.	2		
10 p.m.	29.82	78	0	ne.	1		
11 p.m.	29.83	76	0	sw.	4		
12 mid.	29.84	76	0	sw.	4		

Houston, Texas.
Latitude 29° 47′ N. Longitude 95° 24′ W.
To the right of the line followed by the center of the cyclone, 35 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
22d							
10 p.m.	29.61	68	0	s.	19		
11 p.m.	29.65	68	0	sw.	16		
12 mid.	29.70	69	0	sw.	16		
23d							
1 a.m.	29.71	69	0	sw.	13		
2 a.m.	29.75	69	0	sw.	14		
3 a.m.	29.77	68	0	sw.	14		
4 a.m.	29.79	67	0	sw.	13		
5 a.m.	29.81	68	0	sw.	16		
6 a.m.	29.83	70	0	sw.	12	ci. st.	?
7 a.m.	29.85	74	0	sw.	13	st.	sw.
8 a.m.	29.86	75	0	sw.	11		
9 a.m.	29.88	77	0	sw.	14		
10 a.m.	29.89	78	0	sw.	13		
11 a.m.	29.89	81	0	sw.	12	st. cu.	sw.
12 noon	29.90	82	0	sw.	11		
1 p.m.	29.89	83	0	sw.	12		
2 p.m.	29.88	84	0	sw.	10		
3 p.m.	29.87	85	0	sw.	9		
4 p.m.	29.87	86	0	sw.	10		
5 p.m.	29.86	86	0	w.	8		

Galveston, Texas.
Latitude 29° 18′ N. Longitude 94° 50′ W.
To the right of the line followed by the center of the cyclone, 90 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
22d							
6 p.m.	29.67	76	T.	se.	37		
7 p.m.	29.68	70	.04	s.	23		
8 p.m.	29.70	74	.01	s.	20		
9 p.m.	29.73	74	T.	s.	16		
10 p.m.	29.76	75	T.	s.	16		
11 p.m.	29.78	75	0	sw.	11		
12 mid.	29.79	74	0	sw.	10		
23d							
1 a.m.	29.81	74	0	sw.	9		
2 a.m.	29.82	75	0	sw.	9		
3 a.m.	29.84	75	0	sw.	9		
4 a.m.	29.85	74	0	sw.	7		
5 a.m.	29.86	75	0	sw.	5		
6 a.m.	29.88	75	0	sw.	5		
7 a.m.	29.89	75	0	sw.	5	st. cu.	w.
8 a.m.	29.91	78	0	sw.	6		
9 a.m.	29.92	78	0	sw.	5		
10 a.m.	29.92	79	0	sw.	6		
11 a.m.	29.92	78	0	sw.	5		
12 noon	29.92	80	0	sw.	6	cu.	e.
1 p.m.	29.92	83	0	s.	6		
2 p.m.	29.91	84	0	s.	6		
3 p.m.	29.90	84	0	s.	7		

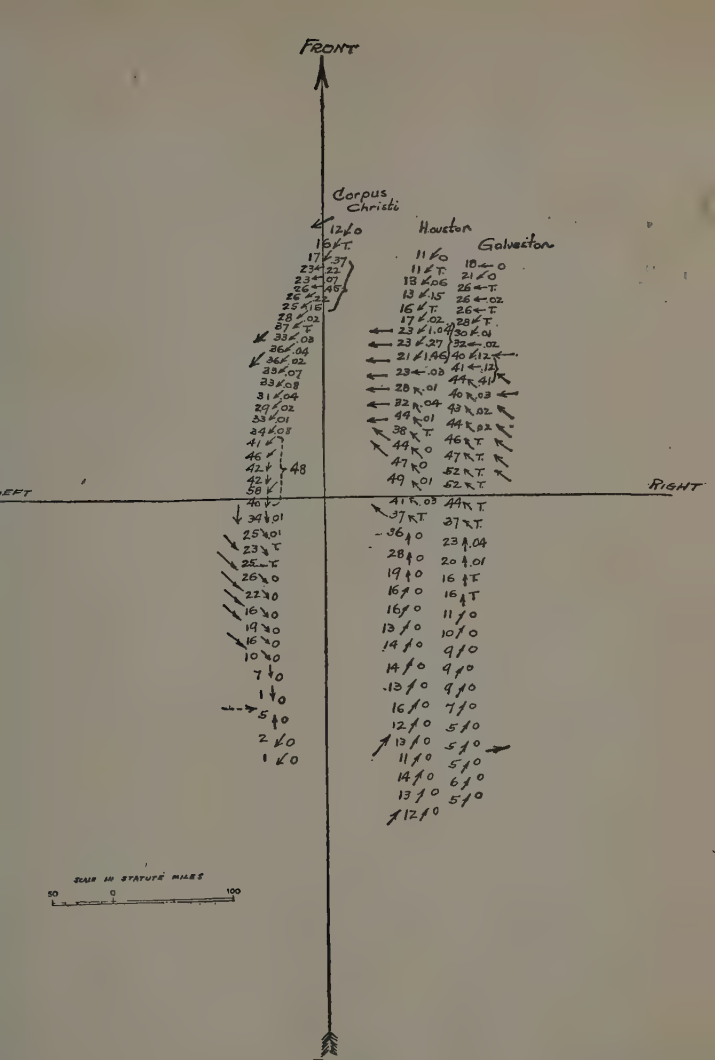


Figure 34. Records made during the passage of the tropical cyclone, June 21-22, 1921. Intersection of cross lines represents the center of the cyclone. Points of small regular arrows rest on positions of stations at the time the records were made; figures to the left of the arrows are wind velocities in miles per hour; figures on the right of the arrows are the hourly precipitation measured to hundredths of an inch. Brackets show greatest precipitation intensity. Heavy arrows represent the directions of the lower clouds; broken arrows represent the directions of upper clouds, the cirrus types. This cyclone followed an exceptional course.

XVIII

Tropical Cyclone in Florida October 23-26, 1921

The tropical cyclone of October 23-26, 1921, (32), moved from the Caribbean Sea northward, curving over the Yucatan Channel, the eastern Gulf of Mexico, northeastward across the central portion of the Florida Peninsula, and thence eastward into the Atlantic Ocean, as shown by path "F," Figure 2. The study of this cyclone is of special interest because of the fact that its course was mainly over the water during the entire period of its existence, the Florida Peninsula being only about 100 miles wide than in a cyclone where no high pressure area was near and the curve in the path of the cyclones was less pronounced.

The hourly wind directions and velocities and precipitation at five stations well distributed in this cyclone are shown on Figure 35. The wind directions in the right rear quadrant are mainly in the same direction as that in which the cyclonic center advanced. In the right front quadrant the wind directions, while the velocity was between 9 and 16 miles per hour, were inclined towards the center, but with the increase in velocity as the center approached the directions were inclined more to the right and for four hours before the passage of the center were across the line of advance. The winds moved around through the left front quadrant into the left rear quadrant where they inclined more to the center and moved directly across the line along which the cyclonic center was advancing. The winds well in the front of this cyclone show the influence of an area of high pressure that was over the northeastern portion of the United States and which influenced the course followed by the cyclone. The winds in the front of this cyclone are inclined more to the center than in a cyclone where no high pressure area was near and the curve in the path of the cyclones was less pronounced.

The directions of the lower clouds in the front half of the cyclone, taken as a whole, showed less inclination towards the cyclonic center than the surface winds. In the rear half the directions of the lower clouds were generally the same as the surface winds. No clouds of the cirrus type with directions were

corded within the limits of this cyclone except at Key West, la., two observations well in front show cirrus clouds moving om the southwest, a direction which the cyclone followed on aching this latitude.

Precipitation commenced at Tampa, Fla., 58 hours before ie passage of the storm center. At this station, in the right alf, the greatest hourly precipitation intensity occurred eight ours before the passage of the cyclonic center, and at Jackson-lle, Fla., in the left half, it occurred five hours before the assage of the cyclonic center. *There was very little precipita-on at any of the five stations after they passed into the rear of e cyclonic area.* This is of special importance because of the nall land area and the fact that the winds were mainly off ater surfaces, both in the right and left halves of the cyclonic ea.

Sufficient pressure readings were made on the Florida Penin-la to permit the drawing of isobars showing the gradients the front half of the storm area as it advanced into the Penin-la, October 25th, and then, in the rear half of the storm ea as the center crossed the Peninsula. The positions of most essel stations in the cyclonic area are too uncertain to permit ie use of their barometer readings in drawing isobars with fficient accuracy for scientific investigation. Chief Officer anton of the American Steamship Truxillo which was about miles due west from Egmont Key, Florida, October 25, 1921, ys:

> "10.20 a. m. Entered storm center, barometer 28.28 inches; no wind, but a terrific cross sea. 10.50 a. m. Passed out of storm center, barometer 28.28 inches; getting wind from west, hurricane force."

The pressure here was 28.28 inches with a dead calm for half hour. The shift of the wind shows this station in the calm ea but a little to the right of the line followed by the center the cyclone.

At Tarpon Springs, Florida, October 25, 1921, the barometer as 28.29 inches at 2.15 p. m. and 28.29 inches at 2.30 p. m. The bserver, Dr. A. P. Albaugh, says:

> "1.20 p. m. Wind southeast and stronger; our highest

wind was from 1.30 to 2.00 p. m.; about 2.15 p. m. wind getting lighter; about 2.40 p. m. almost calm and remained so for one hour or more, then started from the northwest and heightened for one hour or more then grew lighter."

From the shift of the wind mentioned by Dr. Albaugh, Tarpon Springs was evidently a few miles to the left of the line followed by the center of the cyclone. The calm area on the left of the line followed by the center of the cyclone is of longer duration than at stations the same distance from the center on the right side of the path.

The pressure during the passage of this cyclone is represented on maps Figures 36 to 41. Supplemental barometer readings at sub-stations near the center of the cyclone are given in Table XVIII. Within the 29.4 isobar the form of the isobars is nearly circular. A crowding of the isobars appears in the left front of the cyclonic area as shown in Figure 37. The isobars became more crowded and the gradient steepened on the left side as the high pressure area extended southward along the Atlantic Coast during the passage of the cyclone out into the Atlantic Ocean.

TROPICAL CYCLONE IN THE EAST GULF AND SOUTH ATLANTIC REGIONS, OCTOBER 23 TO 26, 1921

BLE XVII — 75th Meridian Time

Charleston, South Carolina.
Latitude 32° 47′ N. Longitude 79° 56′ W.
To the left of the line followed by the center of the cyclone, 240 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
24th							
p.m.	30.01	74	0	ne.	17		
p.m.	30.00	74	0	ne.	16		
p.m.	29.98	73	0	ne.	16		
p.m.	29.98	72	0	ne.	14		
p.m.	29.98	70	0	ne.	10		
p.m.	29.98	69	0	ne.	11		
p.m.	29.97	68	0	ne.	11	st.	sw.
p.m.	29.96	67	0	ne.	10		
p.m.	29.95	67	0	ne.	10		
p.m.	29.94	67	0	ne.	9		
mid.	29.93	67	0	ne.	9		
25th							
a.m.	29.91	67	0	ne.	9		
a.m.	29.89	67	0	ne.	9		
a.m.	29.88	67	0	ne.	10		
a.m.	29.87	67	0	ne.	11		
a.m.	29.86	67	0	ne.	11		
a.m.	29.87	67	.04	ne.	10		
a.m.	29.87	67	.02	ne.	10		
a.m.	29.87	67	0	ne.	11	a. cu.	sw.
a.m.	29.87	71	0	ne.	12	st.	ne.
a.m.	29.87	72	T.	ne.	17		
a.m.	29.86	73	T.	ne.	17		
noon	29.85	71	.03	ne.	18	st.	s.
p.m.	29.82	71	T.	ne.	19	st.	ne.
p.m.	29.80	71	.01	ne.	16		
p.m.	29.78	72	0	ne.	16		
p.m.	29.77	71	0	ne.	21		
p.m.	29.78	70	0	e.	19		
p.m.	29.77	69	0	ne.	16		
p.m.	29.77	70	0	ne.	15		
p.m.	29.77	70	0	ne.	15	st.	ne.
p.m.	29.76	70	T.	ne.	19		
p.m.	29.77	71	T.	ne.	15		
p.m.	29.76	71	.01	ne.	20		

Savannah, Georgia.
Latitude 32° 05′ N. Longitude 81° 05′ W.
To the left of the line followed by the center of the cyclone, 205 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles Per Hour	CLOUDS	
						Kind	Direction
24th							
1 p.m.	29.99	74	0	e.	19		
2 p.m.	29.98	75	0	e.	20		
3 p.m.	29.97	73	0	ne.	16		
4 p.m.	29.96	73	0	ne.	16		
5 p.m.	29.96	72	0	ne.	16		
6 p.m.	29.95	71	0	ne.	15		
7 p.m.	29.95	70	0	ne.	15		
8 p.m.	29.94	70	T.	ne.	13	st.	ne.
9 p.m.	29.93	69	0	ne.	11		
10 p.m.	29.93	68	0	ne.	14		
11 p.m.	29.90	68	T.	ne.	12		
12 mid.	29.87	67	0	ne.	11		
25th							
1 a.m.	29.87	66	T.	ne.	12		
2 a.m.	29.86	66	.03	ne.	6		
3 a.m.	29.85	67	T.	ne.	9		
4 a.m.	29.83	67	0	ne.	12		
5 a.m.	29.83	67	0	ne.	16		
6 a.m.	29.83	67	T.	ne.	11		
7 a.m.	29.82	67	.01	ne.	11	a. st.	e.
8 a.m.	29.82	67	T.	ne.	13	st. cu.	e.
9 a.m.	29.83	67	.12	ne.	15		
10 a.m.	29.82	68	.02	ne.	14		
11 a.m.	29.82	70	T.	ne.	14		
12 noon	29.80	70	0	e.	20	st. cu.	ne.
1 p.m.	29.77	71	T.	ne.	14		
2 p.m.	29.75	68	.14	ne.	18	st.	ne.
3 p.m.	29.74	69	.10	ne.	20		
4 p.m.	29.73	68	T	ne.	22	st.	ne.
5 p.m.	29.71	68	T	ne.	23		
6 p.m.	29.71	68	T	ne.	21		
7 p.m.	29.71	69	T	ne.	21		
8 p.m.	29.71	68	.03	ne.	23	st.	ne.
9 p.m.	29.71	68	.02	ne.	28		
10 p.m.	29.69	69	.01	ne.	26		

TROPICAL CYCLONE IN THE EAST GULF AND SOUTH ATLANTIC REGIONS, OCTOBER 23 TO 26, 1921

TABLE XVII 75th Meridian Time

Charleston, South Carolina. Latitude 32° 47′ N. Longitude 79° 56′ W. To the left of the line followed by the center of the cyclone, 240 miles.								Savannah, Georgia. Latitude 32° 05′ N. Longitude 81° 05′ W. To the left of the line followed by the center of the cyclone, 205 miles.							
Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	CLOUDS		Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	CLOUDS	
						Kind	Direction							Kind	Direction
25th								25th							
12 mid.	29.74	71	T.	ne.	22			11 p.m.	29.67	70	T.	ne.	27		
26th								12 mid.	29.65	70	.01	ne.	27		
1 a.m.	29.74	71	.01	ne.	20			26th							
2 a.m.	29.73	71	.13	ne.	19			1 a.m.	29.65	70	.01	ne.	27		
3 a.m.	29.72	71	.06	ne.	25			2 a.m.	29.65	70	.04	ne.	27		
4 a.m.	29.73	68	.03	ne.	34			3 a.m.	29.64	71	T.	ne.	27	Center	
5 a.m.	29.75	66	.02	ne.	36			4 a.m.	29.65	70	.03	ne.	24	Passed	
6 a.m.	29.78	64	0	ne.	35			5 a.m.	29.67	69	T.	ne.	29		
7 a.m.	29.80	62	0	ne.	36	Center Passed		6 a.m.	29.71	65	.04	ne.	35		
								7 a.m.	29.73	64	.01	ne.	29		
8 a.m.	29.81	62	0	ne.	38	st.	ne.	8 a.m.	29.77	63	0	ne.	29	st. cu.	ne.
9 a.m.	29.83	61	T.	ne.	37			9 a.m.	29.80	61	0	ne.	31		
10 a.m.	29.84	61	0	ne.	38			10 a.m.	29.82	61	0	ne.	29		
11 a.m.	29.84	63	0	ne.	39			11 a.m.	29.83	62	T.	ne.	29		
12 noon	29.84	64	T.	ne.	36	st.	ne.	12 noon	29.83	62	0	ne.	28		
1 p.m.	29.84	65	T.	ne.	36			1 p.m.	29.82	63	0	n.	29	st.	n.
2 p.m.	29.84	65	0	ne.	36			2 p.m.	29.82	63	0	n.	27		
3 p.m.	29.86	66	0	ne.	33			3 p.m.	29.83	64	0	ne.	28		
4 p.m.	29.89	66	0	ne.	31			4 p.m.	29.86	63	0	ne.	28		
5 p.m.	29.90	65	0	ne.	32			5 p.m.	29.88	64	0	ne.	26		
6 p.m.	29.93	66	0	ne.	28			6 p.m.	29.91	64	0	ne.	23		
7 p.m.	29.95	66	0	ne.	31			7 p.m.	29.93	63	0	ne.	24		
8 p.m.	29.95	66	0	ne.	31	st.	ne.	8 p.m.	29.97	62	0	n.	23	st.	n.
9 p.m.	29.97	64	0	ne.	30			9 p.m.	29.99	61	0	n.	20		
10 p.m.	29.98	63	0	ne.	27			10 p.m.	30.00	61	0	n.	20		
11 p.m.	30.00	62	0	n.	27			11 p.m.	30.01	61	0	ne.	19		
12 mid.	30.00	62	0	ne.	28			12 mid.	30.02	61	0	ne.	19		

Jacksonville, Florida.
Latitude 30° 20′ N. Longitude 81° 39′ W.
To the left of the line followed by the center of the cyclone, 95 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
24th							
9 a.m.	30.01	69	.01	n.	2		
10 a.m.	30.02	70	T.	ne.	1	st. cu.	e.
11 a.m.	30.00	71	T.	ne.	2		
12 noon	29.99	73	.01	ne.	2	st. cu.	e.
1 p.m.	29.99	72	T.	ne.	1		
2 p.m.	29.93	71	.01	ne.	2	st. cu.	e.
3 p.m.	29.93	71	.01	ne.	3		
4 p.m.	29.93	70	T.	ne.	3	st. cu.	e.
5 p.m.	29.92	70	T.	ne.	8		
6 p.m.	29.91	70	0	ne.	10		
7 p.m.	29.90	69	0	ne.	10		
8 p.m.	29.89	70	.01	ne.	14	st. cu.	ne.
9 p.m.	29.88	70	.02	ne.	14		
10 p.m.	29.86	70	.02	ne.	13		
11 p.m.	29.85	70	.01	ne.	12		
12 mid.	29.83	71	.02	ne.	14		
25th							
1 a.m.	29.80	72	.01	ne.	16		
2 a.m.	29.78	71	.04	e.	16		
3 a.m.	29.77	70	.01	e.	16		
4 a.m.	29.76	72	.02	e.	15		

Tampa, Florida.
Latitude 27° 57′ N. Longitude 82° 27′ W.
To the right of the line followed by the center of the cyclone, 18 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
24th							
1 a.m.	29.94	70	.02	ne.	12		
2 a.m.	29.94	70	.04	ne.	14		
3 a.m.	29.92	71	.13	ne.	11		
4 a.m.	29.91	71	.05	ne.	16		
5 a.m.	29.91	72	.07	ne.	14		
6 a.m.	29.91	72	.03	ne.	12		
7 a.m.	29.91	72	.08	ne.	11		
8 a.m.	29.90	72	.06	ne.	13	st.	ne.
9 a.m.	29.90	72	.21	ne.	13		
10 a.m.	29.90	71	.35	ne.	14	st.	ne.
11 a.m.	29.89	71	.06	ne.	13		
12 noon	29.87	73	.07	ne.	13	st.	ne.
1 p.m.	29.86	73	.01	ne.	11	st.	ne.
2 p.m.	29.81	73	.18	ne.	13	st.	ne.
3 p.m.	29.79	72	.01	ne.	15		
4 p.m.	29.78	72	.10	ne.	16	st.	ne.
5 p.m.	29.77	72	.10	ne.	15		
6 p.m.	29.76	70	.09	ne.	19		
7 p.m.	29.76	70	.36	ne.	17		
8 p.m.	29.75	70	.27	ne.	16	st.	ne.
9 p.m.	29.75	70	.29	ne.	12		

Key West, Florida.
Latitude 24° 33′ N. Longitude 81° 48′ W.
To the right of the line followed by the center of the cyclone, 212 miles.

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
23d						ci. st.	sw.
11 a.m.	29.91	84	0	se.	15	a. cu.	sw.
12 noon	29.89	85	0	se.	15	st.	se.
						ci. st.	sw.
1 p.m.	29.87	84	0	se.	15	a. cu.	sw.
2 p.m.	29.85	83	0	se.	15	cu.	se.
3 p.m.	29.83	83	0	se.	17	a. st.	nw.
4 p.m.	29.84	83	0	se.	16	a. cu.	s.
5 p.m.	29.86	82	T.	se.	15	cu.	se.
6 p.m.	29.87	81	.01	se.	14		
7 p.m.	29.86	81	.03	se.	15	a. cu.	se.
8 p.m.	29.85	76	.22	se.	17	st. cu.	se.
9 p.m.	29.86	79	0	se.	16		
10 p.m.	29.86	79	0	se.	17		
11 p.m.	29.84	79	0	se.	18		
12 mid.	29.83	79	T.	se.	18		
24th							
1 a.m.	29.82	79	.03	se.	19		
2 a.m.	29.81	79	0	se.	17		
3 a.m.	29.80	80	0	se.	20		
4 a.m.	29.78	80	0	se.	22		
5 a.m.	29.77	80	0	se.	22		

TABLE XVII — Tropical Cyclone in the East Gulf and South Atlantic Regions, October 25 to 28, 1921
75th Meridian Time

Date and Hour	Pressure Inches (Sea Level)	Temperature F.	Precipitation in Inches	Wind Direction	Wind Velocity Miles per Hour	Clouds: Kind	Clouds: Direction
Jacksonville, Florida. Latitude 30° 20′ N. Longitude 81° 39′ W. To the left of the line followed by the center of the cyclone, 95 miles.							
25th							
5 a.m.	29.75	71	.07	e.	17		
6 a.m.	29.76	71	.04	e.	19		
7 a.m.	29.76	72	.03	e.	21		
8 a.m.	29.74	72	.03	e.	23	st. cu.	e.
9 a.m.	29.73	70	.07	e.	23		
10 a.m.	29.72	70	.09	e.	27		
11 a.m.	29.71	71	.09	e.	26		
12 noon	29.68	71	.05	ne.	25	st. cu.	e.
1 p.m.	29.61	70	.11	ne.	28		
2 p.m.	29.56	70	.12	ne.	31	st. cu.	ne.
3 p.m.	29.53	70	.17	ne.	36		
4 p.m.	29.50	70	.33	ne.	40	st. cu.	ne.
5 p.m.	29.48	71	.70	ne.	41		
6 p.m.	29.48	70	.13	ne.	46		
7 p.m.	29.47	70	.82	ne.	44		
8 p.m.	29.44	70	.78	ne.	48	st. cu.	ne.
9 p.m.	29.44	71	.38	ne.	50		
10 p.m.	29.44	70	.53	ne.	46		
11 p.m.	29.42	70	.07	ne.	50	Center	
12 mid.	29.35	70	.07	ne.	55	Passed	
Tampa, Florida. Latitude 27° 57′ N. Longitude 82° 27′ W. To the right of the line followed by the center of the cyclone, 18 miles.							
24th							
10 p.m.	29.74	71	.15	ne.	9		
11 p.m.	29.72	72	.07	ne.	9		
12 mid.	29.69	70	.07	ne.	13		
25th							
1 a.m.	29.68	70	.10	ne.	12		
2 a.m.	29.62	71	.26	ne.	17		
3 a.m.	29.57	71	.29	ne.	19		
4 a.m.	29.48	70	.28	ne.	25		
5 a.m.	29.38	71	.12	ne.	32		
6 a.m.	29.36	71	.46	e.	36		
7 a.m.	29.35	72	.96	e.	28		
8 a.m.	29.31	73	.39	e.	26	st.	e.
9 a.m.	29.28	73	.18	e.	34		
10 a.m.	29.22	74	.35	e.	36	st.	e.
11 a.m.	29.12	74	.46	se.	38		
12 noon	29.04	73	.34	se.	48	st.	se.
1 p.m.	28.92	74	.46	se.	38	st.	e.
2 p.m.	28.84	75	.22	se.	42	st.	se.
3 p.m.	28.84	74	.11	s.	53	st.	s.
4 p.m.	28.91	74	T.	sw.	37		
Key West, Florida. Latitude 24° 33′ N. Longitude 81° 48′ W. To the right of the line followed by the center of the cyclone, 212 miles.							
24th						a. st.	?
						a. cu.	e.
7 a.m.	29.78	80	0	se.	25	st. cu.	se.
8 a.m.	29.78	80	0	se.	25	st.	se.
9 a.m.	29.78	80	0	se.	28	a. cu.	s.
10 a.m.	29.78	81	0	se.	26	st. cu.	s.
11 a.m.	29.77	80	T.	se.	26	st.	s.
						a. st.	sw.
						a. cu.	sw.
12 noon	29.73	81	T.	se.	27	st. cu.	s.
						st.	s.
1 p.m.	29.71	80	0	se.	28	a. cu.	s.
2 p.m.	29.69	80	0	se.	26	st. cu.	s.
3 p.m.	29.67	80	.01	se.	27	a. st.	sw.
4 p.m.	29.66	80	T.	se.	26	st. cu.	s.
5 p.m.	29.65	79	T.	s.	30	Center	
6 p.m.	29.65	79	.01	s.	29	Passed	
7 p.m.	29.65	79	T.	s.	33		
8 p.m.	29.66	79	.01	s.	34	a. st.	s.?
9 p.m.	29.66	78	.01	s.	33	st.	s.
10 p.m.	29.64	78	.03	s.	32		

Jacksonville, Florida.
Latitude 30° 20′ N. Longitude 81° 39′ W.
To the left of the line followed by the center of the cyclone, 95 miles.

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION
26th							
1 a.m.	29.37	73	.01	ne.	44		
2 a.m.	29.38	72	T.	ne.	47		
3 a.m.	29.40	72	T.	ne.	41		
4 a.m.	29.43	70	.09	n.	36		
5 a.m.	29.46	71	.09	n.	40		
6 a.m.	29.50	72	.03	n.	42		
7 a.m.	29.55	73	T.	n.	38		
8 a.m.	29.59	69	.01	n.	35	st. cu.	ne.
9 a.m.	29.63	67	.01	n.	38		
10 a.m.	29.69	65	T.	n.	38		
11 a.m.	29.71	63	.01	n.	37		
12 noon	29.73	63	0	n.	34		
1 p.m.	29.74	64	T.	n.	31	st. cu.	n.
2 p.m.	29.75	65	T.	n.	31		
3 p.m.	29.78	63	T.	n.	29		
4 p.m.	29.80	65	T.	n.	28		
5 p.m.	29.81	63	T.	nw.	25		
6 p.m.	29.85	65	T.	n.	24		
7 p.m.	29.87	66	0	n.	27	st. cu.	n.
8 p.m.	29.90	66	0	n.	27		

Tampa, Florida.
Latitude 27° 57′ N. Longitude 82° 27′ W.
To the right of the line followed by the center of the cyclone, 18 miles.

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION
25th							
6 p.m.	29.10	72	.02	sw.	41		
7 p.m.	29.15	71	T.	sw.	27		
8 p.m.	29.24	71	.01	w.	20	st.	sw.
9 p.m.	29.30	71	.01	w.	23		
10 p.m.	29.34	71	T.	w.	21		
11 p.m.	29.38	71	0	w.	19		
12 mid.	29.39	71	0	w.	16		
26th							
1 a.m.	29.41	71	0	w.	18		
2 a.m.	29.44	71	0	w.	18		
3 a.m.	29.47	71	T.	w.	19		
4 a.m.	29.49	70	T.	w.	19		
5 a.m.	29.53	70	0	w.	17		
6 a.m.	29.57	71	0	w.	15		
7 a.m.	29.60	73	0	w.	14		
8 a.m.	29.64	72	0	w.	15	st. cu.	nw.
9 a.m.	29.66	72	0	w.	13		
10 a.m.	29.69	73	0	w.	14		
11 a.m.	29.70	74	0	w.	15		
12 noon	29.71	75	0	w.	13	st. cu.	nw.

Key West, Florida.
Latitude 24° 33′ N. Longitude 81° 48′ W.
To the right of the line followed by the center of the cyclone, 212 miles.

DATE AND HOUR	PRESSURE INCHES (SEA LEVEL)	TEMPERATURE F.	PRECIPITATION IN INCHES	WIND DIRECTION	WIND VELOCITY MILES PER HOUR	CLOUDS	
						KIND	DIRECTION
25th							
1 a.m.	29.60	80	T.	s.	40		
2 a.m.	29.60	80	T.	s.	39		
3 a.m.	29.56	80	T.	s.	41		
4 a.m.	29.55	80	0	s.	44		
5 a.m.	29.57	80	0	s.	42		
6 a.m.	29.57	80	0	sw.	42		
7 a.m.	29.59	81	0	sw.	42		
8 a.m.	29.61	81	0	sw.	42	st. cu.	sw.
9 a.m.	29.63	81	0	sw.	38		
10 a.m.	29.64	81	0	sw.	36		
11 a.m.	29.64	82	0	sw.	38	ci.	0?
12 noon	29.61	82	0	sw.	37	a. cu.	w.
1 p.m.	29.60	82	0	sw.	37	st. cu.	sw.
2 p.m.	29.58	79	T.	sw.	37	st. cu.	sw.
3 p.m.	29.59	80	.06	sw.	34		
4 p.m.	29.59	78	.01	sw.	36	st. cu.	sw.
5 p.m.	29.61	79	.02	sw.	36		
6 p.m.	29.62	77	T.	sw.	31		
7 p.m.	29.64	78	.01	w.	30	a. st.	w.
8 p.m.	29.65	79	T.	sw.	27	st. cu.	sw.
9 p.m.	29.66	78	.04	sw.	25		

TABLE XVIII

BAROMETER READINGS AT SUBSTATIONS IN FLORIDA DURING THE PASSAGE OF THE TROPICAL CYCLONE, OCTOBER 25, 1921. THE DISTANCE OF THE STATIONS TO THE RIGHT OR LEFT OF THE LINE FOLLOWED BY THE CENTER OF THE CYCLONE IS GIVEN SUPPLEMENTAL TO TABLE XVII.

75th Meridian Time

DATE AND HOUR	TARPON SPRINGS ON THE LINE FOLLOWED BY THE CENTER	DUNEDIN 5 MILES TO THE RIGHT	SAFETY HARBOR 7 MILES TO THE RIGHT	EGMONT KEY 30 MILES TO THE RIGHT	FORT MYERS 190 MILES TO THE RIGHT
OCT. 25th					
7:30 a.m.	.....	29.34	.....	.....	.....
8:00 a.m.	.....	29.32	.....	.....	29.43
8:30 a.m.	.....	29.24	29.23	.....	.....
9:00 a.m.	.....	29.22	.....	.....	.....
9:30 a.m.	.....	29.14	29.18	.....	29.42
10:00 a.m.	.....	29.09	.....	.....	.....
10:15 a.m.	.....	.....	.....	28.95	.....
10:30 a.m.	.....	29.04	29.09	28.94	29.41
10:40 a.m.	.....	.....	.....	28.90	.....
10:50 a.m.	29.07	.....	.....	.....	.....
11:00 a.m.	.....	28.98	.....	.....	.....
11:15 a.m.	.....	.....	.....	28.86	.....
11:30 a.m.	.....	28.84	28.94	28.84	.....
11:45 a.m.	28.98	.....	.....	.....	.....
12:00 noon	28.87	28.76	.....	28.82	29.37
12:30 p.m.	28.75	28.64	28.77	.....	.....
12:40 p.m.	28.72	.....	.....	.....	.....
12:50 p.m.	28.63	.....	.....	.....	.....
1:00 p.m.	.....	28.52	.....	28.90	.....
1:05 p.m.	28.53	.....	.....	.....	.....
1:15 p.m.	.....	.....	.....	28.92	.....
1:20 p.m.	28.47	.....	.....	.....	.....
1:30 p.m.	28.42	28.42	28.58	28.94	29.37
1:50 p.m.	28.34	.....	.....	.....	.....
2:00 p.m.	.....	28.34	28.51	.....	.....
2:15 p.m.	28.29	.....	.....	.....	.....
2:30 p.m.	28.29	28.54	28.57	.....	29.38
2:55 p.m.	28.39	.....	.....	.....	.....
3:00 p.m.	.....	28.74	.....	29.00	.....
3:30 p.m.	.....	28.90	28.83	.....	29.39
4:00 p.m.	.....	28.94	.....	.....	.....
4:30 p.m.	.....	28.99	28.99	.....	.....
4:50 p.m.	28.87	.....	.....	.....	.....
5:00 p.m.	.....	29.04	.....	.....	29.40
5:30 p.m.	.....	29.08	29.07	.....	.....

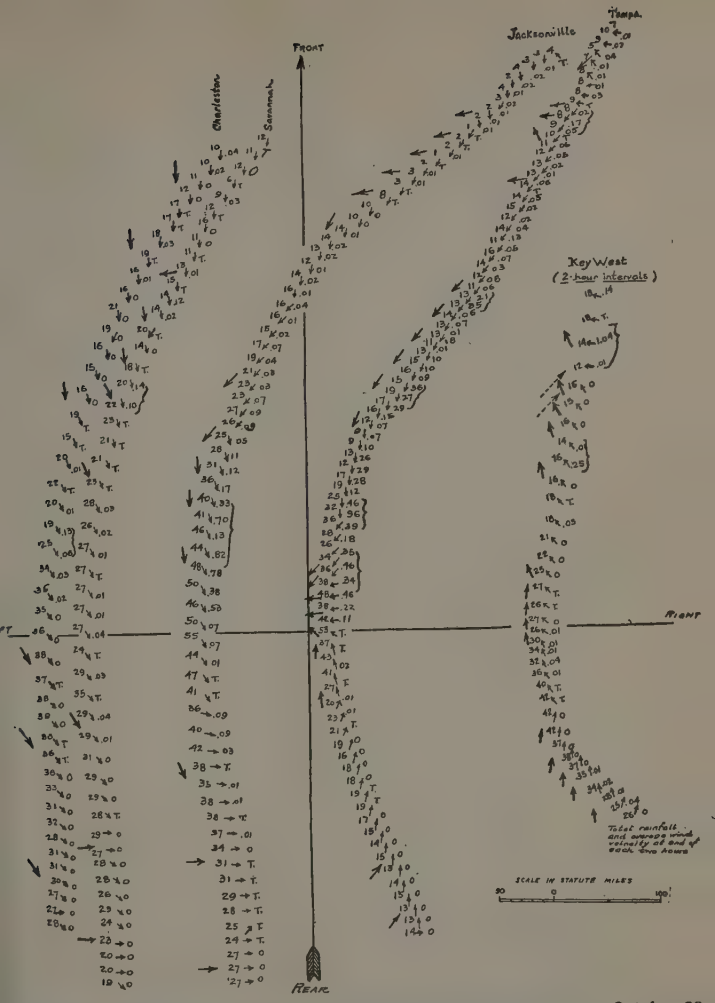


Figure 35. Records made during the passage of the tropical cyclone, October 23 to 26, 1921. Intersection of cross lines represents the center of the cyclone. Points of small regular arrows rest on positions of stations at the time the records were made; figures on the left of the arrows are wind velocities in miles per hour; figures on the right of the arrows are the hourly precipitation measured to hundredths of an inch. Brackets show greatest precipitation intensity.

Heavy arrows represent the directions of the lower clouds.

Broken arrows represent the directions of the upper clouds, the cirrus types.

This cyclone falls in the group of larger traveling cyclones and moved mainly over water

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

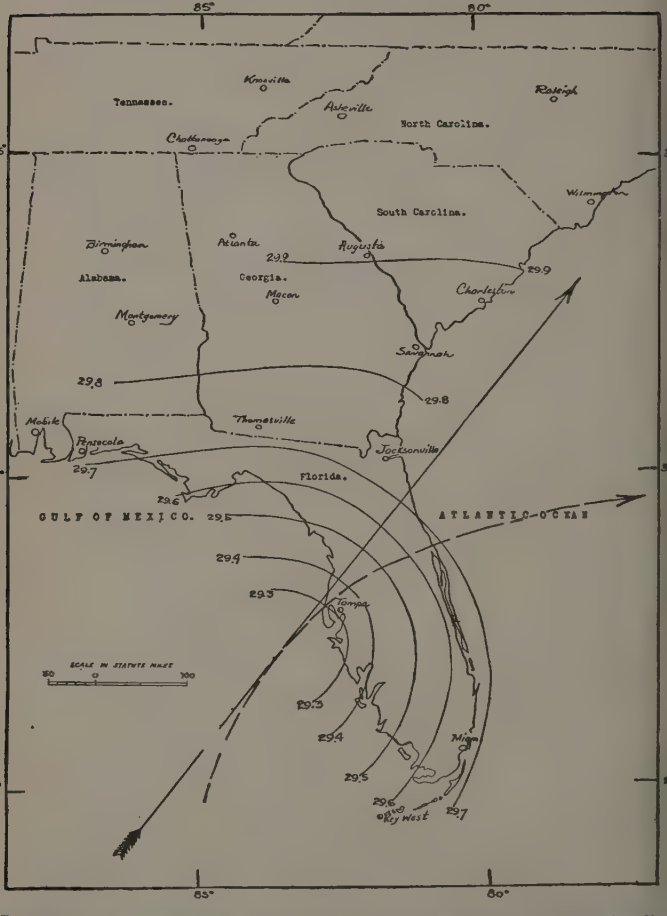


Figure 36. Pressure distribution, 8:00 a.m., October 25, 1921, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at 8:00 a.m.

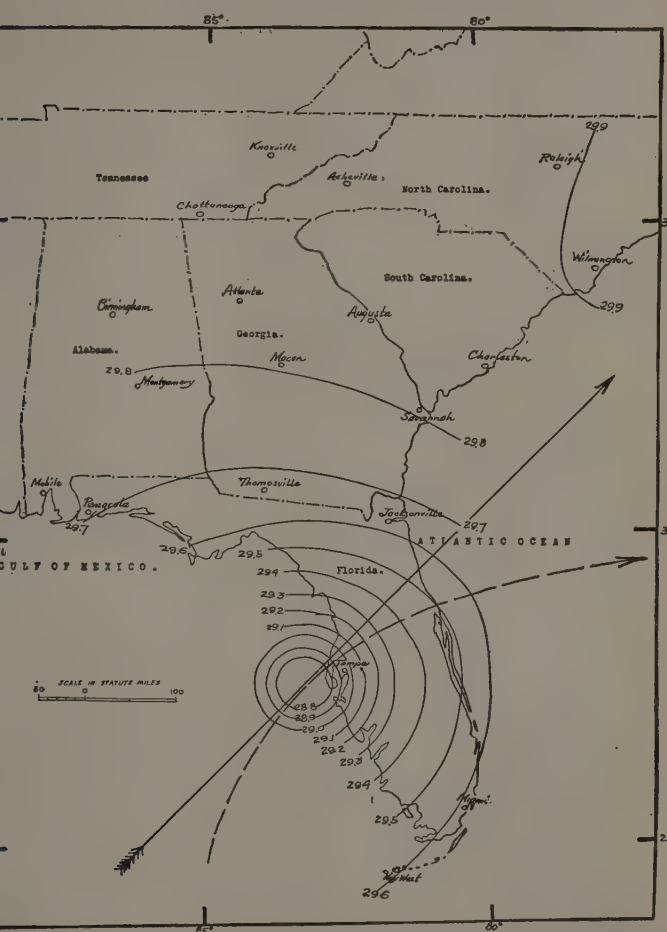


Figure 37. Pressure distribution, 12 noon, October 25, 1921, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at noon.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

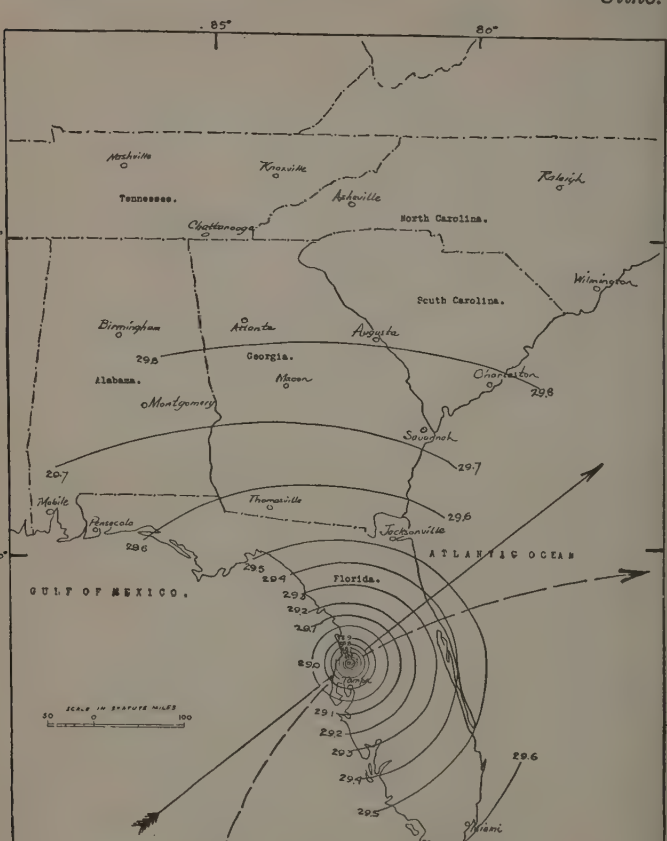


Figure 38. Pressure distribution, 4:00 p.m., October 25, 1921, 75th Meridian Time. Isobars are drawn for each .10 of an inch. Broken line is path followed by the cyclonic center. Solid line with arrow indicates the direction of movement of the cyclonic center at 4:00 p.m.

OPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS
—*Cline.*

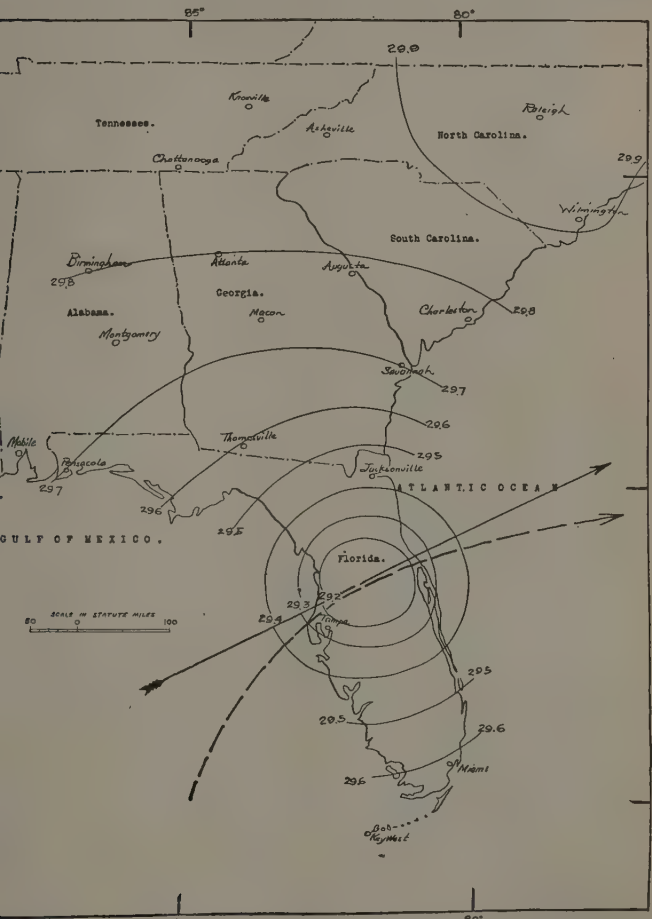


Figure 39. Pressure distribution, 8:00 p.m., October 25, 1921, 75th Meridian ne. Isobars are drawn for each .10 of an inch. Broken line is path followed the cyclonic center. Solid line with arrow indicates the direction of movement the cyclonic center at 8:00 p.m.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

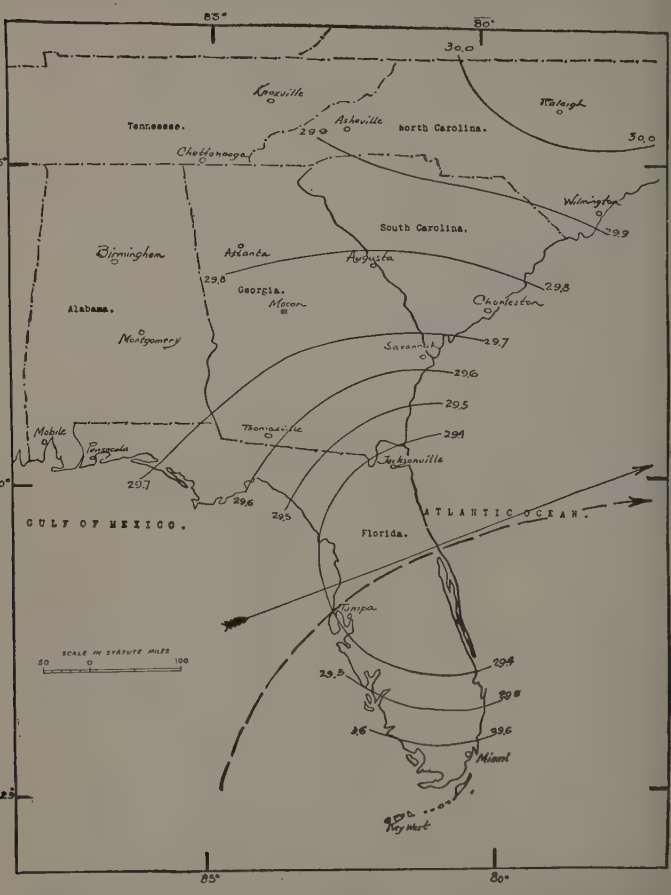


Figure 40. Pressure distribution, 12 Midnight, October 25-26, 1921, 75th Meridi Time. Isobars are drawn for each .10 of an inch. Broken line is path followed the cyclonic center. Solid line with arrow indicates the direction of movement the cyclonic center at 12 Midnight.

OPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

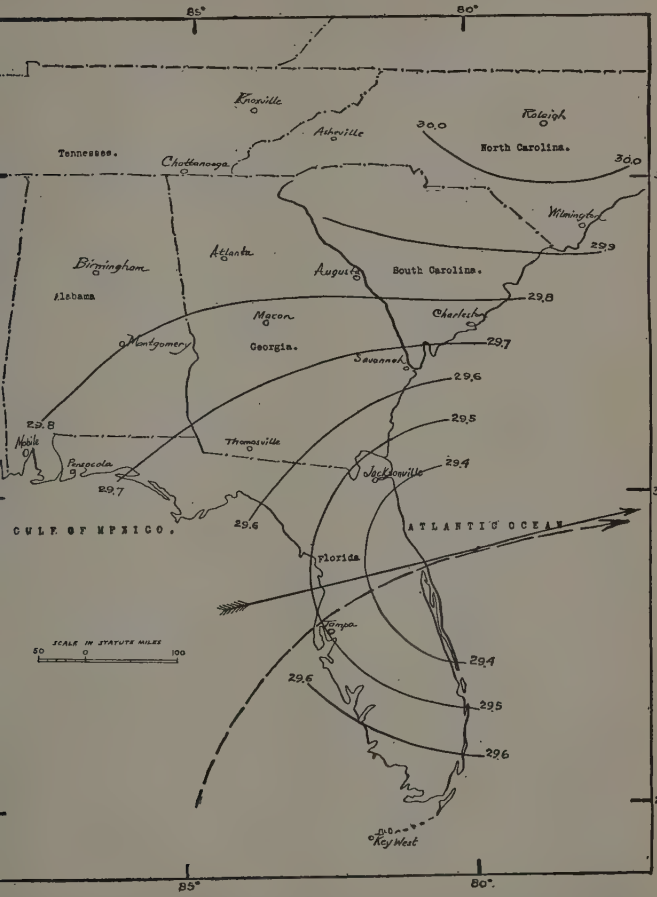


Figure 41. Pressure distribution, 4:00 a.m., October 26, 1921, 75th Meridian ne. Isobars are drawn for each .10 of an inch. Broken line is path followed by cyclonic center. Solid line with arrow indicates the direction of movement of cyclonic center at 4:00 a.m.

XIX

Tropical Cyclone in the Caribbean Region October 14-19, 1922

A tropical disturbance which appeared in the Caribbean Sea October 14, 1922, immediately southwest of Jamaica, moved slowly westward and crossed the Yucatan Peninsula on the 18th and 19th, and then traveled southwestward over the western Gulf of Mexico and the Bay of Campeche into Mexico. The course followed by this cyclone is so unusual that it is mentioned here in connection with cirrus cloud directions recorded at New Orleans, La., showing the movements of upper air currents at this time.

October 17, 1922, stratus clouds obscured the sky in the early part of the forenoon, and in passing off revealed cirrus clouds moving from the northeast. No clouds were visible during the 18th. About noon of the 19th the writer noted cirrus clouds moving with exceptional rapidity from the northeast and by 2 p. m. the sky was eight-tenths covered. An observer was sent to the nephoscope to measure the velocity and he reported the velocity based on the cirrus level to be 140 miles per hour. The first assistant and other observers checked this record and found it correct. The rate of travel was so great that the following note was made in the daily journal of the New Orleans Station October 19, 1922:

> "Cirrus clouds were observed at noon; changing in a few hours into cirro-stratus. Computed on the average cirrus level (10,000 meters) the velocity at 2 p. m. would have been shown as 140 miles per hour from the northeast. This velocity, however, appeared so extraordinary that it was then assumed that the cirrus clouds were not much above the average alto-stratus level, (5000 meters) and the velocity was therefore made of record, 70 miles from the northeast. (Computations were made and checked by several assistants.)"

The upper air current moving from the northeast over New Orleans October 17 to 19, no doubt was the cause of the unusual course followed by this cyclone.

XX

INDS AND PRECIPITATION IN FOUR OF THE LARGER TRAVELING CYCLONES

The winds in the individual storms have well defined similar aracteristics in the different parts of the cyclonic area. In der to study these characteristics of the winds more closely the veral cyclones of about the same size and type have been mbined on one chart. Eleven of the sixteen tropical cyclones nsidered in the foregoing parts of this study fall into three ell defined classes when size and movement are considered.) Large cyclones, those with a diameter greater than 450 iles, which continued to advance after moving inland. (b) nall cyclones, those with a diameter of 300 to 450 miles, that ntinued to advance after reaching land. (c) Small cyclones nich did not continue to advance on moving inland. The ameter of the area in which well defined cyclonic conditions evailed is considered as the diameter of the cyclone.

Six of the cyclones under consideration have diameters greater an 450 miles and these are classed as large traveling cyclones. ne paths followed by the centers of these cyclones are shown Figure 2, paths "A" to "F," inclusive.

The hourly wind directions and velocities recorded at the veral stations during the passage of four of the large cyclones which we have complete automatic records are combined on e chart in Figure 42. It is remarkable how uniformly the nd directions recorded in the different cyclones conform and ree in the different parts of the cyclonic area on this combined art. In the right rear quadrant all the winds have the same neral direction as that in which the cyclonic center advanced. me of these cyclones curved rather abruptly to the right ter passing the stations of observation, thus carrying the sta- ns as they fall back in the rear across the right quadrant. here the records of stations in the curving storms are carried ross the records from other stations in other storms of other ars the wind directions fall in line with each other and coin-

cide as accurately as the direction of one hour follows the preceding hour at the same station in the same storm.

In the August 17-22, 1915, cyclone, Galveston and Houston, Texas, are carried back across the right rear quadrant and when they come in line with records made at New Orleans and Burrwood, La., Mobile, Ala., and Pensacola, Fla., in the cyclone of September 19-20, 1909, and the cyclone of September 29-30, 1915, the wind directions coincide as closely as if they were at the same station in the same cyclone. In the October, 1921, cyclone, records for Key West, Fla., cross those for Mobile, Ala., and Pensacola, Fla., in the cyclone of September 19-20, 1909, and the wind directions coincide as of the same cyclone.

An examination of the movement of the winds in the right half of the combined chart reveals decided changes in directions as related to the cyclonic center which so far as we know have not been brought out previously in the study of winds in cyclones. In the region where the winds of the right rear quadrant pass into the right front quadrant there is a decided shift to the left in a very limited space. The change of direction in this region within 150 miles on the right of the cyclonic center, which includes all observations within that distance of the center, amounts to 90 degrees change in direction in 20 to 70 miles in space and three to eight hours in time. It is also seen that these winds come into this region with generally high velocities and at times 100 miles per hour is exceeded. More than 150 miles to the right of the center of the cyclone a shift of 90 degrees or nearly that amount occurs in 8 to 12 hours' time. Where there is such a decided general change of wind direction with high velocity in so short a space and time as occurs within 200 miles to the right of the center there is of necessity convergence and ascending air.

The wind directions of the different cyclones, as shown in the front half of the combined chart, fall in together with as much uniformity as appears in the charts of the individual cyclones, with the sole exception of the cyclone of October 23-27, 1921, in which the winds in the front were influenced by an area of high pressure as previously mentioned.

In the left rear quadrant the winds take up a course which carries them with comparatively low velocities almost directly

across the line of advance of the center, where they curve into the winds of much greater velocity of the right rear quadrant in a manner nearly uniform in all the cyclones. The winds of smaller velocity in the left rear quadrant are drawn in by the winds of higher velocity in the right rear quadrant, which minimizes the effects of the rather sharp convergence in the rear of the cyclone and there is on this account probably little or no ascending air in this area as a result of this convergence. The highest sustained wind velocities at all stations in all storms are shown in the right rear quadrant. The next highest velocities are in the right front quadrant. The velocities in the left half are not nearly so great as in the right half. The agreement in the wind directions and velocities in the different parts of this chart made up by a combination of different large storms shows conclusively that this chart represents as closely as we can determine from available data the actual wind directions and velocities which prevail at short intervals of time and space in different parts of tropical cyclones with diameters greater than 450 miles while traveling through these latitudes. In the smaller cyclones we have on the combined chart more complete data in the left half near the center of the cyclone.

The hourly precipitation records at the several stations in the four large traveling cyclones are combined on one chart in Figure 43. Only light precipitation is recorded in the rear half of the cyclones except at one station several hundred miles to the right of the line of advance of the center, where there was probably a secondary disturbance in the cloud region over that part of the cyclonic area.

The precipitation of greatest intensity occurs in the right front quadrant in all of these cyclones and the position of the hourly precipitation intensity at the several stations falls in together so regularly that it appears as the precipitation of one individual cyclone. The greatest hourly precipitation intensity in the large traveling cyclone is about 80 miles in space and 7 to 10 hours in time in advance of the cyclonic center and to the right of the line along which the center was advancing when it occurred. The hourly precipitation exceeds one-third of an inch over an area 100 miles in width and 250 miles in length commencing in the front and extending well across the right

front quadrant. Half an inch or more falls in one hour over an area 50 miles wide and 150 miles long extending from the line along which the center is advancing, to the right across the right front quadrant; this heavy rain area commences about 100 miles in front of the line dividing the cyclone into front and rear halves.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

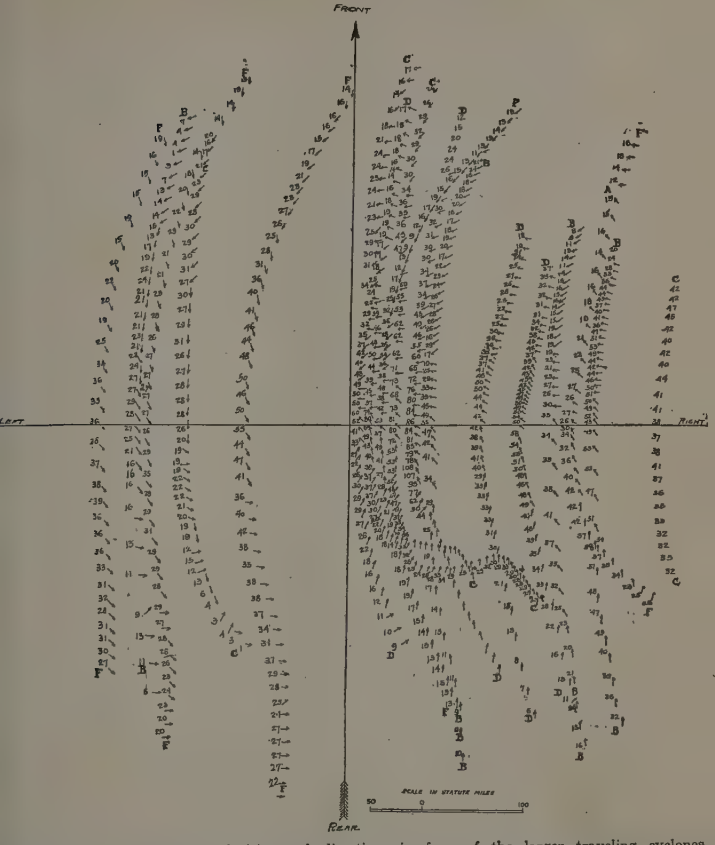


Figure 42. Hourly wind velocities and directions in four of the larger traveling cyclones (those having diameters of more than 450 miles) combined. This chart shows that the wind directions of the several quadrants in different cyclones at different stations, fall in line with each other regardless of the time, place, or direction of movement. This chart represents as nearly as we can ascertain the winds at short intervals of time and space in the larger traveling cyclones. The storms used in this chart are as follows:

B.—Stations in the Louisiana cyclone, September 19-21, 1909, left to right, Galveston, Texas; New Orleans, Louisiana; Mobile, Alabama; and Pensacola, Florida. See chart figure 5.

C.—Stations in the Texas cyclone, August 16-18, 1915, left to right, Corpus Christi, Texas; Houston, Texas; Galveston, Texas; and Burrwood, Louisiana. See chart figure 8.

D.—Stations in the Louisiana cyclone, September 27-30, 1915, left to right, New Orleans, La.; Burrwood, La.; Mobile, Ala.; and Pensacola, Florida. See chart figure 21.

F.—Stations in the Florida cyclone, October 23-26, 1921, left to right, Charleston, South Carolina; Savannah, Georgia; and Jacksonville, Tampa, and Key West, Florida. See chart figure 35.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

Figure 43. Hourly precipitation in four of the larger traveling cyclones (those havi diameters of more than 450 miles) combined on one chart. The greatest precipitation intens (see brackets) occurs in the right front quadrant in all of these cyclones. There is no precipit tion of consequence in the rear half of the cyclonic area. This chart represents the distributi of precipitation as it actually occurs in the traveling cyclone as nearly as we can expect determine.

B.—Stations in the Louisiana cyclone, September 19–21, 1909, left to right, Galveston, Tex New Orleans, Louisiana; Mobile, Alabama; and Pensacola, Florida. See chart figure 5.

C.—Stations in the Texas cyclone, August 16–18, 1915, left to right, Corpus Christi, Tex Houston, Texas; and New Orleans, Louisiana. See chart figure 8.

D. Stations in the Louisiana cyclone, September 27–30, 1915, left to right, New Orlea Louisiana; Mobile, Alabama; and Pensacola, Florida. See chart figure 21.

F. Stations in the Florida cyclone, October 23–26, 1921, left to right, Charleston, So Carolina; Savannah, Georgia; and Jacksonville, Tampa, and Key West, Florida. See ch figure 35.

XXI

Winds and Precipitation in Four Smaller Traveling Cyclones

There were four traveling cyclones similar in character which had diameters between 300 and 450 miles and which continued to advance after moving inland, and their paths are shown by "G" to "J," inclusive, Figure 2. The hourly wind directions and velocities at the several stations in these four cyclones are combined on one chart in Figure 44. The wind directions at all stations in the right rear quadrant in all these cyclones fall into the same direction as that in which the cyclonic center advanced, as was the case in the larger cyclones. In the right front quadrant the winds show a decided change in direction near the line dividing the cyclone into front and rear halves about the same as in the large traveling cyclones. The wind directions in the left half agree closely with those in the larger cyclones, moving around the center through the left front quadrant into the left rear quadrant where they turn towards the center and blow directly across the line of advance and curve into the winds of the right rear quadrant.

The distribution of hourly precipitation at stations in the four cyclones, 300 to 450 miles in diameter, has been combined on one chart in Figure 45. Only light precipitation is recorded in the rear half of the cyclonic area. The precipitation of greatest intensity in these smaller traveling cyclones is recorded directly in front of the center and to the right and it occurs two to five hours before the center of the cyclone reaches the stations. The most intense precipitation occurs nearly twice as far in advance of the center in the large as compared with the smaller traveling cyclones.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

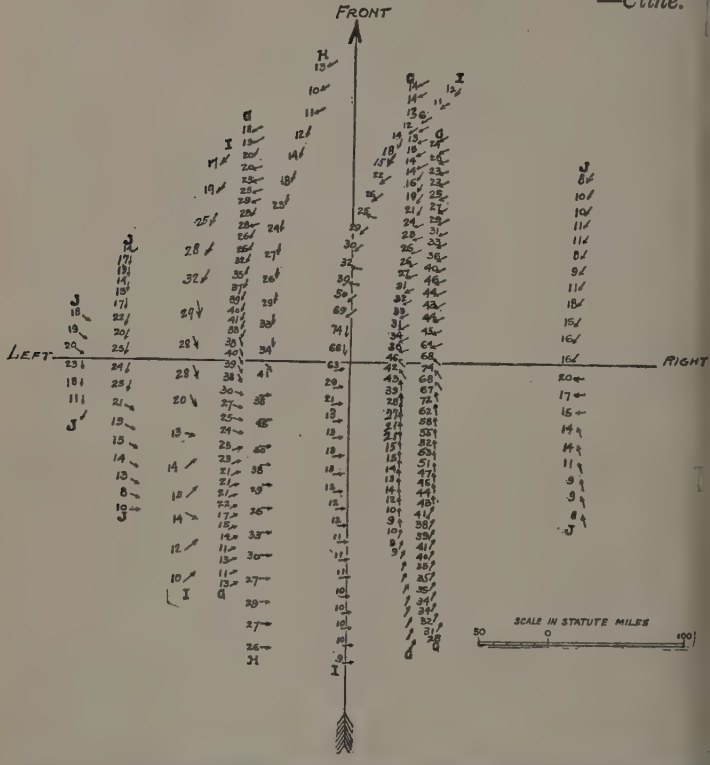


Figure 44. Hourly wind velocities and directions in four of the smaller traveling cyclones (those having diameters between 300 and 450 miles) combined. This chart shows a general agreement of the wind directions of the several quadrants, in different cyclones at different stations; it represents as nearly as we can expect to ascertain the winds at short intervals of time and space in different parts of the smaller traveling cyclones.

G.—Stations in the middle Gulf coast cyclone, September 26-27, 1906, left to right, New Orleans, Louisiana; Mobile, Alabama; and Pensacola, Florida. See chart figure 3.

H.—Key West in the Florida Straits cyclone, October 17-18, 1906. See chart figure 4.

I.—Stations in the Florida Straits cyclone, October 10-12, 1909, left to right, Key West, and Jupiter, Florida. See chart figure 6.

J.—Stations in the east Gulf coast cyclone, September 2-4, 1915, left to right, Mobile, Alabama; and Pensacola and Tampa, Florida. See chart figure 20.

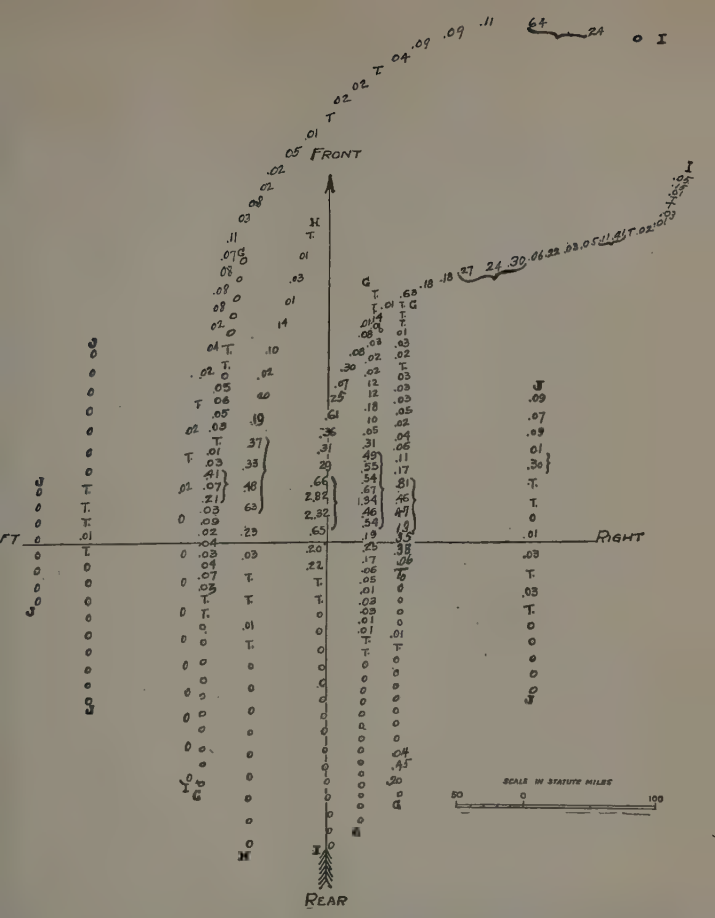


Figure 45. Hourly precipitation in four of the smaller traveling tropical cyclones (those having diameters between 300 and 450 miles) combined. The greatest precipitation intensity (in brackets) occurs in the front and right front quadrant in all the cyclones. There is no precipitation of consequence in the rear half of the cyclonic area. This chart represents the distribution of precipitation as it actually occurs in the smaller traveling cyclones as nearly as we can expect to determine.

G.—Stations in the middle Gulf coast cyclone, September 26-27, 1906, left to right, New Orleans, Louisiana; Mobile, Alabama, and Pensacola, Florida. See chart figure 3.

H.—Key West in the Florida Straits cyclone, October 17-18, 1906. See chart figure 4.

I.—Stations in the Florida Straits cyclone, October 10-12, 1909, left to right, Key West, and Jupiter, Florida. See chart figure 6.

J.—Stations in the east Gulf coast cyclone, September 2-4, 1915, left to right, Mobile, Alabama; and Pensacola and Tampa, Florida. See chart figure 20.

XXII

Small Traveling Cyclones with Irregular Movements

There were two tropical cyclones, that of September 27-29, 1917, with a diameter of about 350 miles, and that of June 21-22, 1921, with a diameter of about 200 miles, that continued to advance after moving inland. These cyclones, because of their peculiar movement and the course of their paths, have not been combined on the chart with the other small cyclones. However, the winds in the different parts of these cyclones were not different from those recorded in the other traveling cyclones and the precipitation occurred mostly in the front of the cyclonic area as shown on charts in Figures 32 and 34, where data for these cyclones are presented. There was a small cyclone August 5-6, 1918, probably 100 miles in diameter, which advanced inland for about 200 miles and died out. This cyclone was so small that it falls in a class by itself; the winds and precipitation are shown on Figure 33. The paths followed by these three cyclones are shown by paths "N," "O," and "P," Figure 2.

XXIII

ropical Cyclones Which Ceased to Advance on Moving Inland

There were three small tropical cyclones which did not con-nue to advance on moving inland and they have general char-cteristics in common. The paths of these cyclones are shown y paths "K," "L," and "M," on Figure 2. The hourly wind rections and velocities recorded at stations during the passage these cyclones are combined on one chart in Figure 46. The inds in the right rear quadrant were in the same general direc-on as that in which the cyclone was advancing, the same as the cyclones which continued to advance. In the right front uadrant and the left half of the cyclonic area, the wind direc-ons were more around the cyclonic center than was the case in clones which continued to advance.

The hourly precipitation in the three cyclones which did not dvance on moving inland is shown on one chart in Figure 47. ere the precipitation is not confined to any particular part the cyclonic area as it is in the traveling cyclones. The eatest hourly precipitation intensity is shown in the various arts of the cyclonic area without that systematic distribution hich is found in cyclones which continue to advance.

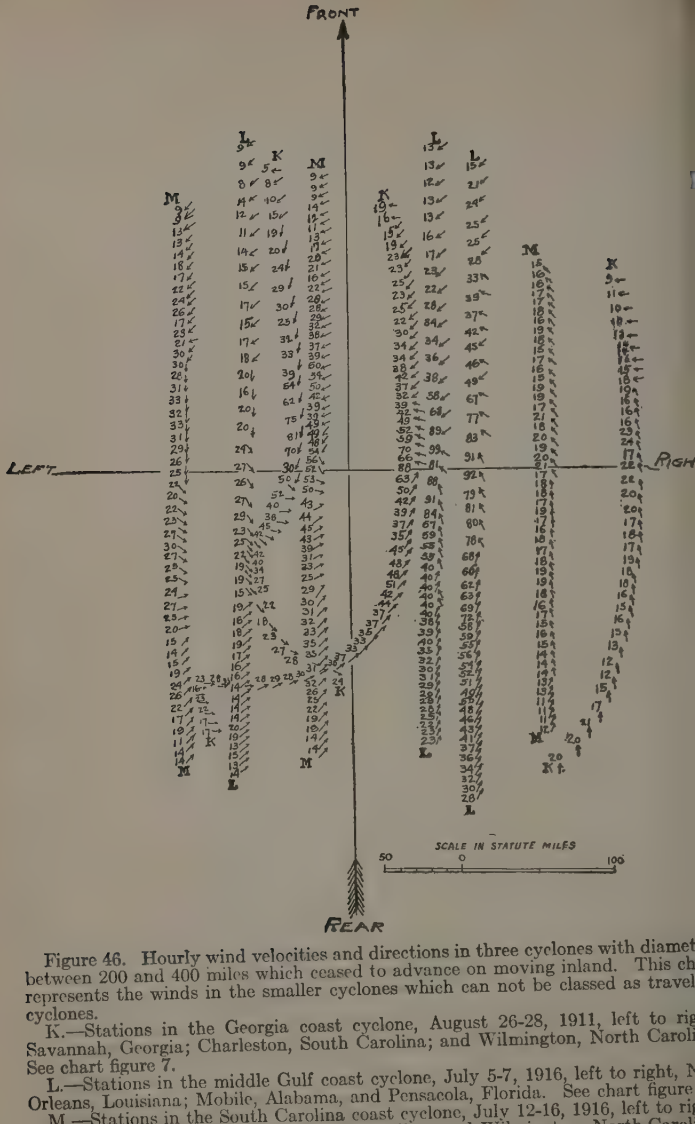


Figure 46. Hourly wind velocities and directions in three cyclones with diamet between 200 and 400 miles which ceased to advance on moving inland. This ch represents the winds in the smaller cyclones which can not be classed as travel cyclones.

K.—Stations in the Georgia coast cyclone, August 26-28, 1911, left to rig Savannah, Georgia; Charleston, South Carolina; and Wilmington, North Caroli See chart figure 7.

L.—Stations in the middle Gulf coast cyclone, July 5-7, 1916, left to right, N Orleans, Louisiana; Mobile, Alabama, and Pensacola, Florida. See chart figure

M.—Stations in the South Carolina coast cyclone, July 12-16, 1916, left to rig Savannah, Georgia; Charleston, South Carolina; and Wilmington, North Carol See chart figure 31.

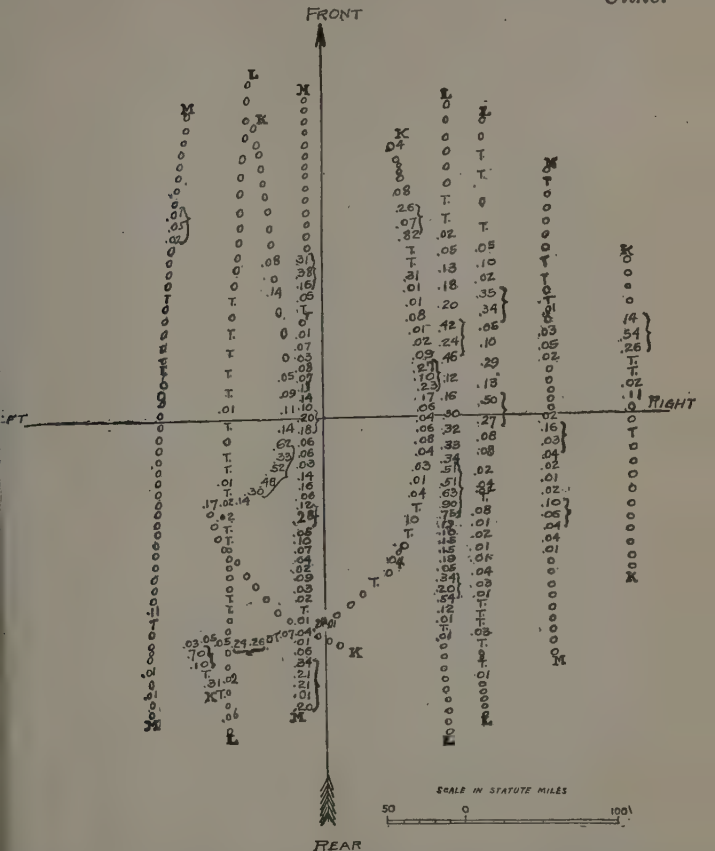


Figure 47. Hourly precipitation in three cyclones with diameters between 200 and 400 miles which ceased to advance on moving inland. This chart shows the hourly precipitation as distributed (Greatest precipitation intensity bracketed) in cyclones which can not be classed as traveling cyclones. The distribution of precipitation in this class of cyclones is materially different from that in a traveling cyclone. There is as much or more precipitation in the rear of the cyclone which ceases to advance as in the front while in the traveling cyclone heavy precipitation occurs in the right front quadrant and there is very little precipitation in the rear half of the cyclone.

K.—Stations in the Georgia coast cyclone, August 26-28, 1911, left to right, Savannah, Georgia; Charleston, South Carolina; and Wilmington, North Carolina. See chart figure 7.

L.—Stations in the middle Gulf coast cyclone, July 5-7, 1916, left to right, New Orleans, Louisiana; Mobile, Alabama; and Pensacola, Florida. See chart figure 30.

M.—Stations in the South Carolina coast cyclone, July 12-16, 1916, left to right, Savannah, Georgia; Charleston, South Carolina, and Wilmington, North Carolina. See chart figure 31.

XXIV

Movement of Clouds in Six of the Larger Traveling Cyclones

The directions of the lower and upper clouds in six of the larger traveling cyclones are charted in Figure 48. The lower clouds over the right rear quadrant move in the same general direction as the surface winds, in the line of advance of the cyclonic center. In front of the cyclone the lower clouds are inclined more to the right than the surface winds. In the left rear quadrant the lower clouds move mainly with the surface winds.

A striking feature in connection with these larger traveling cyclones is that the upper clouds (cirrus types) both in the front and the rear of the cyclones have in the main the same general direction as that in which the cyclones traveled. There were 68 observations of cirrus clouds recorded in connection with the six larger cyclones; 50 of these cirrus observations were in the front half and 18 in the rear half of the cyclonic area; 57 had directions with slightly varying inclinations mainly the same as that in which the cyclones were traveling, leaving only 11 observations of cirrus with directions not in accord with that of the cyclonic progression.

There were four observations of cirrus in the right front quadrant, three in the right rear quadrant and one in the left rear quadrant which have directions to the right across the line along which the cyclone was advancing, and these directions are the prevailing directions of the cirrus for these latitudes. In the left front quadrant there are three observations of cirrus moving off to the left across the line followed by the cyclonic center. There is generally little cloudiness in the left rear quadrant of the cyclonic area and it is interesting to note that there have been only two observations of cirrus recorded in that part of the cyclonic area in these cyclones. No radial outflow of cirrus appears in the records of these cyclones.

The intermediate clouds (the "alto-" types) recorded in the

ix larger cyclones are combined on one chart on Figure 49. The louds of this class recorded in front of these cyclones, with few xceptions, are inclined away from the cyclonic center. In the ight rear quadrant, the intermediate clouds move forward in he same general direction as that in which the cyclone traveled.

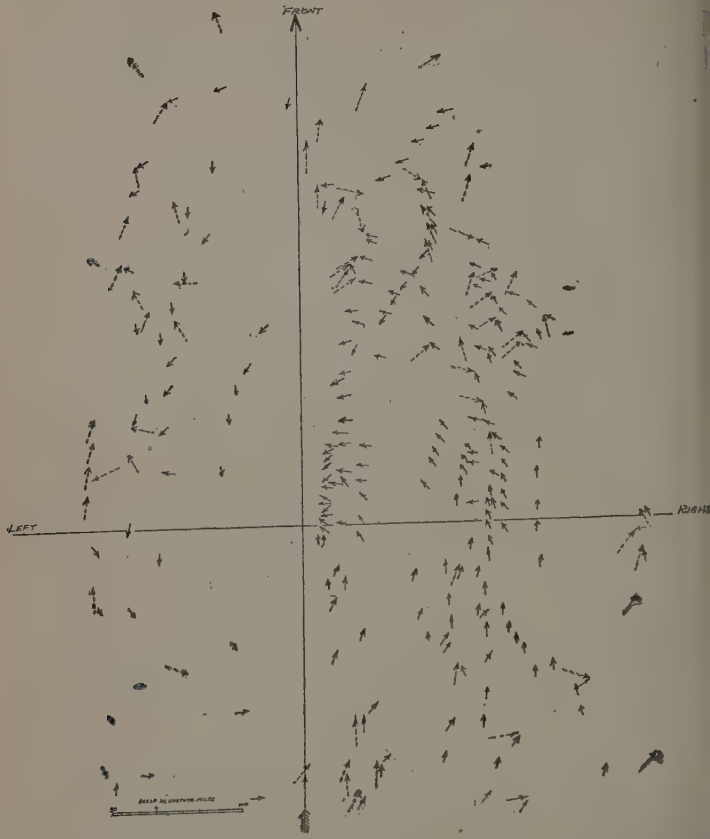


Figure 48. Directions of the winds above the earth's surface in cyclones as shown by observations in six of the larger traveling tropical cyclones, combined: September 5-10, 1900; September 17-21, 1909; August 15-22, 1915; September 27-30, 1915; September 8-15, 1919; and October 23-27, 1921. Solid arrows show directions of lower clouds and broken arrows the directions of the upper clouds, the cirrus types

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

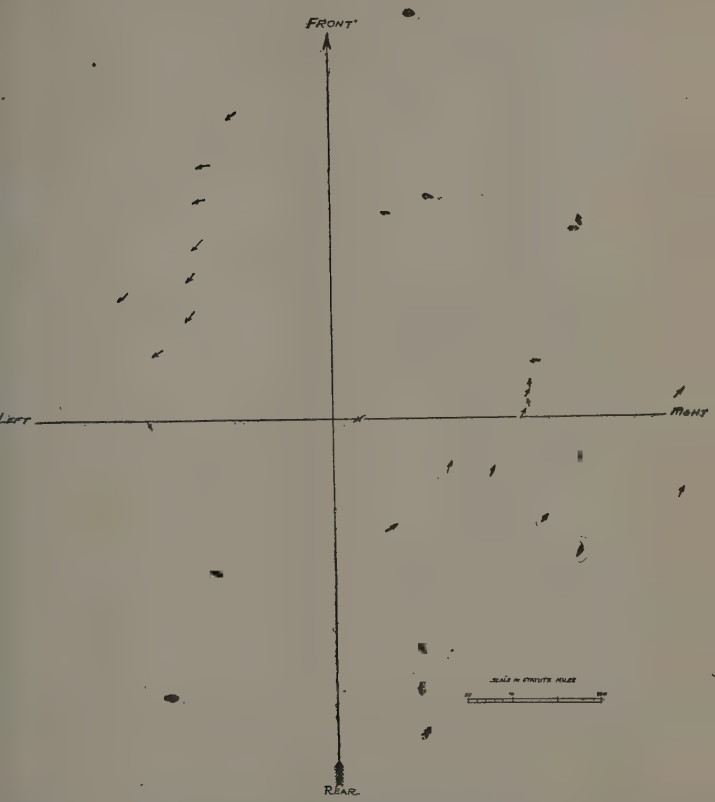


Figure 49. Directions of winds above the earth's surface in the middle regions as shown by the alto-cumulus and alto-stratus clouds in cyclones from observations at stations in six of the larger traveling tropical cyclones, combined: September 5-10, 1900; September 17-21, 1909; August 15-22, 1915; September 27-30, 1915; September 13-15, 1919; and October 23-27, 1921.

XXV

Cloud Movements in Six of the Smaller Traveling Cyclones

The directions of the lower and upper clouds recorded in the six traveling cyclones with a diameter between 200 and 450 miles are combined on one chart in Figure 50. The directions of the lower clouds in the front of the cyclonic area show less inclination towards the center than the surface winds, in fact, there is no incurvature towards the cyclonic center apparent in the cloud directions in the region of these clouds. The upper (cirrus type) clouds in the front of these cyclones are generally across the line of advance but are somewhat inclined in the direction in which the cyclonic center is advancing. The cirrus recorded in the rear of these cyclones generally have directions which carry them across the line along which the cyclonic area is advancing, some directly across, some inclined backward and some forward. The cirrus clouds observed in the cyclones having a diameter less than 450 miles generally have the west to east direction which prevails at the cirrus level in these latitudes and they do not appear to have any relation to this cyclonic circulation unless in the front they have a tendency towards the direction in which the cyclone is traveling. It would appear that the circulation in cyclones of this class is mainly below the cirrus level. In considering all the upper cloud directions in the thirteen traveling cyclones individually and collectively there is nothing to indicate that there is an outflow of cirrus clouds radiating from the center in all directions.

TROPICAL CYCLONES IN THE GULF AND SOUTH ATLANTIC REGIONS —*Cline.*

Figure 50. Directions of winds above the earth's surface in cyclones as shown by observations at stations in seven of the smaller traveling cyclones combined: September 24-29, 1906; October 17-19, 1906; October 10-12, 1909; September 3-5, 1915; September 27-29, 1917; August 5-6, 1918; and June 19-30, 1921. Solid arrows show directions of lower clouds and broken arrows the directions of upper clouds, the cirrus types.

XXVI

Cloud Movements in Cyclones Which Ceased to Advance

The directions of the lower clouds in the three cyclones which ceased to advance after moving inland are mainly with the surface winds. The cirrus clouds in these cyclones have directions which are generally opposed to the line of advance of the cyclonic area, as they show an inclination towards the rear of the cyclone in most cases. See figures 7, 30, and 31.

XXVII

Cloud Observations

The preceding discussion covers 25 years' records and it will be many years before any great amount of additional data in tropical cyclones can be added. The cloud observations recorded in these charts represent the work of something like 100 observers of the Weather Bureau. The manner in which the cloud directions, made at the different stations in different cyclones, fall in together on the combined charts shows how carefully and correctly the observers have recorded the directions of the clouds, and this stands as a high testimonial to the care and accuracy of the observers of the Weather Bureau who have made these observations during the cyclones of the last 25 years.

The directions of cirrus clouds are usually the most difficult to obtain with accuracy and a few irregularities may possibly be accounted for by this fact. However, cirrus clouds being nearly always observed in advance of hurricanes and generally considered as evidence of the movement of cyclones, greater vigilance is exercised by observers and a high degree of accuracy in such cloud records is to be expected. I am convinced that future charts of cloud movements in cyclones will confirm the records made during the period covered by this study.

XXVIII

Temperature in Cyclones

The temperatures as shown by the thermograph records at important positions in the cyclonic area are given for the large traveling cyclones on Figure 51; for the smaller traveling cyclones, on Figure 52; for the smaller cyclones which did not advance on moving inland, on Figure 53. These show the temperature oscillations and changes from the front to the rear of the cyclone at varying distances from the cyclonic center. The changes in the temperature during the passage of these cyclones appear to result mainly from dense cloudiness which retards insolation. No polar front is indicated by the temperature records.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

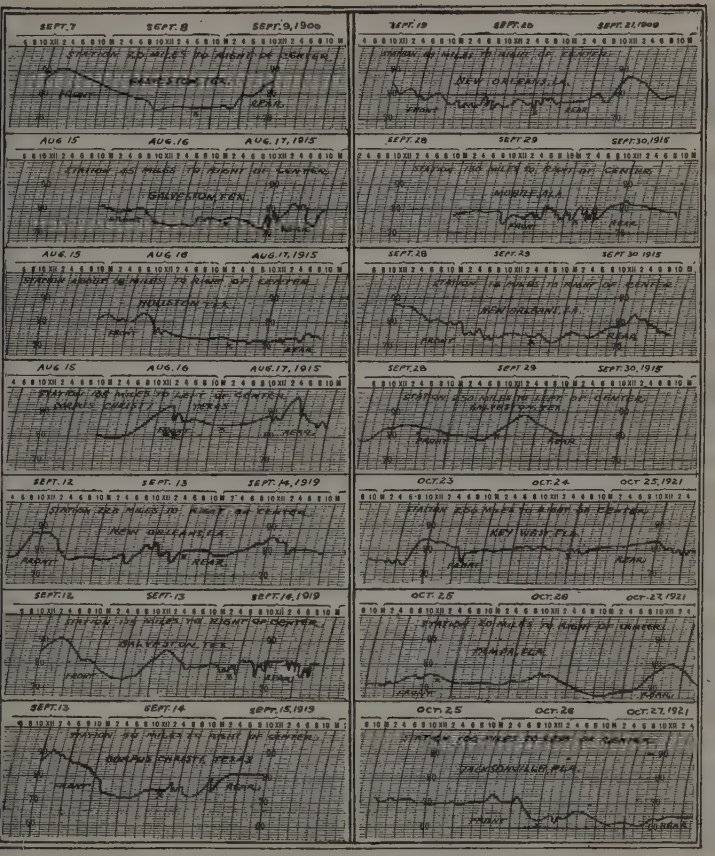

SEPT. 7 SEPT. 8 SEPT. 9, 1900
STATION 200 MILES TO RIGHT OF CENTER
GALVESTON TEX.
FRONT
REAR
SEPT. 19 SEPT. 20 SEPT. 21, 1909
NEW ORLEANS LA.
AUG 15 AUG. 16 AUG. 17, 1915
STATION 45 MILES TO RIGHT OF CENTER
GALVESTON, TEX.
SEPT. 28 SEPT. 29 SEPT. 30, 1915
MOBILE ALA.
AUG. 15 AUG. 16 AUG. 17, 1915
HOUSTON TEX.
SEPT. 28 SEPT. 29 SEPT 30 1915
NEW ORLEANS, LA.
AUG 15 AUG. 16 AUG. 17, 1915
CORPUS CHRISTI, TEXAS
SEPT. 28 SEPT. 29 SEPT. 30, 1915
GALVESTON, TEX.
SEPT. 12 SEPT. 13 SEPT. 14, 1919
NEW ORLEANS, LA.
OCT. 23 OCT. 24 OCT. 25, 1921
KEY WEST, FLA.
SEPT. 12 SEPT. 13 SEPT. 14, 1919
GALVESTON, TEX.
OCT. 25 OCT. 26 OCT. 27, 1921
TAMPA, FLA.
SEPT. 13 SEPT. 14 SEPT. 15, 1919
CORPUS CHRISTI, TEXAS
OCT. 25 OCT. 26 OCT. 27, 1921
JACKSONVILLE, FLA.

Figure 51. Temperatures at one to three stations, in various parts of the cyclonic area, during the passage of each of the six larger traveling tropical cyclones.

The X indicates the time the station passed from the front into the rear half of the cyclonic area.

These were all traveling cyclones.

Tropical Cyclones in the Gulf and South Atlantic Regions —*Cline.*

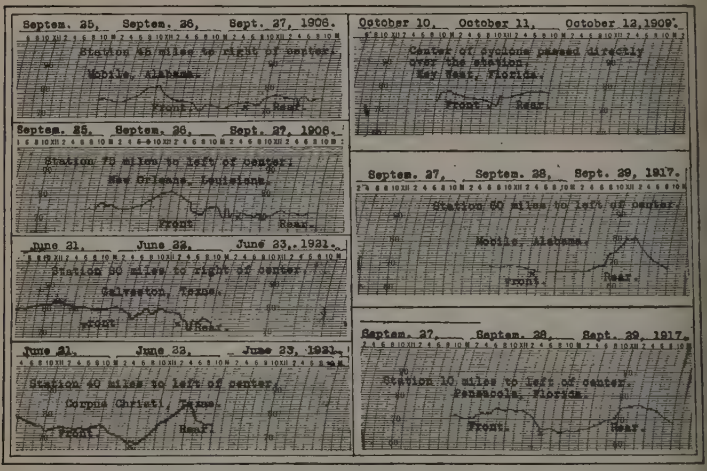


Figure 52. Temperatures at one or two stations, in various parts of the cyclonic area, during the passage of each of four smaller traveling tropical cyclones.

The X indicates the time the station passed from the front into the rear half of the cyclonic area.

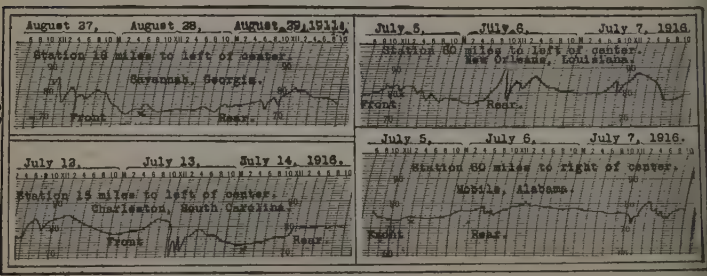


Figure 53. Temperatures at one to two stations, in various parts of the cyclonic area, during the passage of each of the three smaller cyclones which ceased to advance after moving inland.

The X indicates the time the station passed from the front into the rear half of the cyclonic area.

SECTION FOUR

Summary and Conclusions

From a careful study of all the available records charted in their exact relation to the position and direction of movement of the center at the time, in the fourteen cyclones for which there are complete data, we find that the wind directions and the distribution of precipitation in the traveling cyclones summarized in the following conclusions differ materially from the published charts illustrating the spiral inward movement of winds and the distribution of precipitation in cyclones, which heretofore have been based on synoptic charts of widely scattered observations.

It is a general maxim of physical science that the same cause will always produce the same effect. We have found in studying the charted data certain well defined conditions repeatedly occurring in the same portion of different cyclones with similar progressive movement, in different years and in different localities. Some definite forces acting in the line of advance and within the cyclonic area itself cause these well defined conditions of wind and precipitation to occur in the same portion of all traveling cyclones whether over land or water.

Pressure

1. The pressure distribution and the shapes of isobars in three of the largest tropical cyclones where we have exceptionally complete records of the pressure during the passage of the cyclone show that the isobars in these cyclones are nearly circular from the center outward to 29.4 inches, inclusive. Outside the 29.4 inch line the isobars show a crowding on one side and a spreading on the other side; and this crowding and spreading shift positions as the cyclone changes direction of travel.

2. While advancing in a westerly direction, these cyclones show a crowding of the isobars in the right side, and the spreading out in the form of a bulge in the left rear quadrant; while curving the crowding of the isobars shifts across the front of the cyclone; after the recurve when the cyclones are advancing

in a northeasterly direction there is a crowding of the isobars on the left side and a spreading out forming a bulge in the right rear quadrant. The crowding and bulging shift gradually during the recurve and these are probably the result of the forces which determine the direction of movement of the cyclone.

The cyclones curve as they pass inland and move across the United States in a northerly or northeasterly direction, except where important neighboring high pressure areas are a factor in determining the direction of movement of the cyclone, and the cyclones where such high pressure exists generally travel eastward under and in front of the high pressure areas, but in some instances the cyclones are carried to the westward.

The barometric gradients, in the cyclones where we have complete records near the center, average .02 of an inch per mile from the center outward over a distance of 60 miles. The steepest barometric gradients are not found in the immediate vicinity of the cyclonic center but are 15 to 40 miles from the center.

In four instances where the cyclonic center passed directly over the observing station observations show in the central part of the cyclone an area of 8 to 12 miles in diameter where there was a calm or little wind and in which there was no change in the pressure for a period of about half an hour. However, there is not a single instance of record in any of these sixteen cyclones to indicate the semblence of an "eye of the storm," as an area with little or no cloudiness.

3. The filling up of the cyclones commenced at the center with the isobars immediately around the center disappearing and the diameters of the remaining isobars gradually diminishing as the cyclones decreased in intensity.

Winds in Cyclones

4. The wind directions in the traveling cyclones do not show a uniform spiral inward movement around the cyclonic center. A study of the individual traveling cyclones shows that there is a systematic difference in the inclination of the winds towards the center in the different quadrants.

The winds in the right rear quadrant in all of the eleven traveling cyclones blow in the same general direction as that

in which the cyclonic center is traveling and continue to do so during the life of the cyclones. These winds in the right rear quadrant of the cyclone blowing continuously in the line of advance of the cyclonic center form an important systematic and continuous air stream in that part of the cyclonic area. The winds forming this air stream move forward through the right rear quadrant with velocities of 40 to 100 miles per hour or more, and come into convergence with the winds in the right front quadrant, in the neighborhood of the line dividing the cyclone into front and rear halves. This convergence will be discussed more fully under the distribution and causes of precipitation.

The winds in the right front quadrant of the traveling cyclones show considerable uniformity as regards the several cyclones; there are variable inclinations towards the center and within 100 miles of the center the winds move almost directly across the projected line along which the center is advancing. There is greater variability of wind direction in the front of cyclones which have a decided curve in their path than in those with a straighter path; this variability appears to result from the influences of neighboring high pressure areas which also determine to some extent the curve of the path and the directions of movement of the cyclone. The winds after crossing the line of advance into the left front quadrant move around the cyclonic center and through the left rear quadrant where they take up a course nearly across the line of advance; and after crossing the line along which the center is advancing they curve somewhat sharply into and merge with the winds of the right rear quadrant.

From personal contacts with tropical cyclones we have observed that the winds in the right front quadrant differ in their movements and actions from the winds in the other quadrants; in the right front quadrant the winds blow intermittently in sudden, narrow, and powerful gusts, lasting but a few seconds. The sudden gusts are from varying directions, causing the wind-vane to oscillate rapidly and sharply, and they have a much greater velocity than the greatest single mile velocity. These sudden gusts appear to have an ascending or lifting action. In the larger cyclones the gusts are noticeable when the cyclonic

center is 100 to 150 miles distant and in the smaller cyclo
when the cyclonic center is 50 to 100 miles distant.

Charts of the winds in the cyclones which traveled across
in the neighborhood of the Florida Straits show that in t
latitude and over water areas the winds have the same gene
directions as related to the cyclonic center as are found
cyclones moving in on the Gulf Coast farther north.

The storm tides recorded on the coast of the Gulf and So
Atlantic States preceding and accompanying the tropi
cyclones have occurred without exception in the same posit
as related to the cyclonic center (2), rising in the front and
the right of the line of advance of the cyclonic center. The
in the tide commences regularly on the Gulf coast soon a
the cyclones enter the Gulf of Mexico. The occurrence of
storm tides in this manner furnishes conclusive proof that
winds in the right rear quadrant of the cyclonic area are in
same general direction as that in which the cyclone is advanc
when the cyclone enters the Gulf of Mexico. The action of
storm tides indicates that a circulation in cyclones similar
that found to exist in latitudes 25° to 30° extends southward
latitude 20°.

Investigations of cyclones in the Caribbean region show t
the circulation of winds is generally the same in the tropi
cyclones while traveling through that region as that found
the cyclones while traveling through the Gulf and South Atla
regions. Maxwell Hall (40) in referring to the incurvature
winds in tropical cyclones at Jamaica says, "But in most tropi
hurricanes the incurvature is least in front and greatest in rea
Hall was a first-hand investigator on the ground in the trop
and his conclusions regarding wind directions in cyclones
the Caribbean Sea are similar to what we find in the travel
cyclones in the Gulf and South Atlantic regions.

The wind velocities are much greater in the right half th
in the left half of the cyclonic area, and the greatest sustain
wind velocities occur as a rule in the right rear quadrant.
the larger cyclones the greatest wind velocities are found ab
fifty miles to the rear and about the same distance to the ri
of the line of advance of the cyclonic center. In the smal
cyclones the greatest velocities are nearer the cyclonic cen

but the greatest sustained velocities are in the right rear quadrant.

Wind velocities appear to diminish more rapidly at stations passing out through the rear of the cyclone on or only a short distance to the right of the line along which the center is advancing than at stations at a greater distance to the right of that line. New Orleans, La., September 20, 1909; Key West, Fla., October 11-12, 1909; New Orleans, La., September '29, 1915; and Tampa, Fla., October 23, 1921; passed out through the rear of the cyclone, a short distance in each case, to the right of the line along which the center was advancing at the time and the wind velocities at these stations decreased much more rapidly than at stations farther to the right of the line of advance and at a greater distance from the center. These stations were during this time in the region where the winds of the left rear quadrant curve into and merge with the winds of the right rear quadrant.

Upper air observations of the wind directions over cyclonic areas are not available except that the cloud directions observed during the passage of cyclones show the wind directions at the elevations of the clouds which are visible. The directions in which the lower clouds and the cirrus clouds moved in the cyclones during the last 25 years, give valuable information in this connection. In the front and the rear of the large traveling cyclones the cirrus clouds, with few exceptions, travel forward in the same general direction as that in which the cyclone is advancing.

The lower clouds in the front half of the cyclone, from which rain is falling, generally not more than half a mile above the earth's surface, are inclined more to the right than the surface winds. In the left rear quadrant the lower clouds move mainly with the surface winds. In the right rear quadrant of all the large cyclones the lower clouds, the middle clouds, and the cirrus clouds have the same general direction as the surface winds and move in the same direction as that in which the cyclone is traveling. This is an important fact to bear in mind in the study of this subject, because this shows the depth of the air stream in the right rear quadrant of the cyclone.

The wind directions in traveling cyclones at the earth's surface

as charted in this study show that Ferrel, nearly fifty years a in his theory, "Resultants of Cyclonic and Progressive Motio (4), as applied by him to the winds in the cyclone while movi through the trade winds, had a very clear conception of t winds as they actually blow in traveling cyclones.

The greatest deviation from Ferrel's theory is found in t right rear quadrant of the cyclonic area where the charted fa show that in that part of the cyclonic area the winds form air stream which moves forward with velocities of 40 to 1 miles per hour during the life of the cyclone, moving contin ously in the same general direction as that in which the cyclo travels.

Influence of Air Currents in Which the Cyclone Trave

5. It is of primary importance that the causes for the var tions in the angles of inclination of the wind directions fou to exist in the different quadrants of the cyclonic area be co sidered in drawing conclusions.

First-hand investigators, working on the ground, do not fi the trade winds prevailing from the northeast over the W Indies and the Caribbean Sea as is usually implied in meteo logical text books. Notwithstanding Ferrel (4) more than third of a century ago called attention to the fact that the trad do not prevail from the northeast in all regions in which th are supposed to blow, and stated that the prevailing winds ov the West Indies and the Caribbean Sea are from the east, a later observed facts assembled by able meteorologists and pu lished show that the prevailing directions based on observatio at fixed stations are from east to southeast, some meteorologi writers still present the view that northeast winds prevail ov these regions during the greater part of the year. It appe that, especially during the summer months, easterly trades wou be a more correct designation for the steady winds of that regi in the Atlantic Ocean between latitudes 10° and 25° north.

Fassig (35) says: "The prevailing direction of the wi throughout the year in Porto Rico is between east and sou east." The prevailing direction is from the east during Ju July, and August, an equal number of times from the east a southeast in September, and from the southeast in Octob

For a period of 12 years the prevailing wind was not from the northeast in a single month during the hurricane season. On the contrary, as the hurricane season advanced the wind direction shifted farther away from the northeast towards the southeast.

Maxwell Hall (40) in speaking of the trade winds says:

> "But over the Caribbean Sea there is a constant drift which blows over Jamaica from the east-southeast during the hurricane months of August, September, and October; and although on the Plains it is subject to the irregularity of the land and sea breezes, yet at higher elevations it is much more regular; and for the general reduction of observations it was assumed that the constant drift flows at the rate of 8 miles per hour."

The direction of the winds over the Caribbean Sea as shown above is an important factor in determining the courses followed by tropical cyclones moving through those regions. The air current in which the cyclone travels and which determines the direction of progression is found in the prevailing winds at the surface and for some distance above in the regions through which the cyclone is traveling. These are, first the trade winds in the Caribbean Sea mostly from the east to southeast, and then in the Gulf region the summer monsoonal winds, a continuation of the trade winds coming in on the coast from the southeast and south, and these finally shifting by way of southwest into the winds of the middle latitudes moving from west towards the east. This air current not only varies from month to month but may vary in the same month. The air currents a mile or more above the earth's surface in the region of the rain clouds largely determine the direction towards which the cyclonic area advances.

The trade winds have an average velocity over Porto Rico, 10 to 12 miles per hour from east to southeast (35), and 8 miles per hour over Jamaica, (40), from the east-southeast, during the hurricane season; the summer monsoonal winds, a continuation of the trades, come in on the Texas Coast with a velocity of 10 to 16 miles per hour from the southeast to south. Cyclones while in these regions move forward generally with the

velocity of these winds and travel in the direction in which the winds blow, which is usually sufficient evidence to sustain the opinion that these winds carry the cyclones forward. Cyclones move slowly while curving to the eastward; this occurs when the south winds merge with the southwest and west winds and the front of the cyclonic area comes under the influence of the westerly winds of the middle latitudes. After the cyclone curves it travels in an easterly direction; the direction and rate of advance is determined by the direction and velocity at some distance above the earth's surface, of the winds of the middle latitudes. Doberck (9) in his studies of "Storms of the Eastern Seas," and Algue (10) in "Cyclones of the Far East," reached conclusions that the prevailing winds of the region carry the cyclones forward. Hildebrandsson (36) says that the great currents of the atmosphere are indicated by the movements of the cyclones and anticyclones and by the mean direction of the clouds.

The trade winds merging with the monsoonal winds over the Gulf region, and the monsoon merging with the winds of the middle latitudes (4), form an almost continuous air current with a curve similar to the parabola, and the same curve as that generally followed by tropical cyclones. The prevailing winds at Porto Rico show a shifting from eastward to the southeast in September, and the prevailing wind for October is from the southeast, and at Jamaica, the prevailing wind is east-southeast, important facts to bear in mind in the study of this subject.

During the months of June, July, and August, while the prevailing winds at Porto Rico are from the east, about 70% of the tropical cyclones observed in the Leeward Islands and the Caribbean Sea have moved well westward into the Gulf of Mexico before recurving. During September, when the prevailing winds are half of the time from the east and half of the time from the southeast, about 50% of the cyclones observed in the above mentioned regions moved well westward in the Gulf of Mexico before recurving. During October, when the prevailing winds at Porto Rico are southeast and the winds are from the south one-fourth of the time, only 25% of the cyclones observed in the Leeward Islands and the Caribbean Sea have moved west of Long. 85° before recurving. The p

vailing winds in Jamaica during the hurricane season do not vary greatly from those in Porto Rico and it is interesting to note how closely the changes in the paths followed by the tropical cyclones observed in the Leeward Islands and the Caribbean Sea follow the changes in the prevailing wind directions in these regions as the season advances.

When a cyclone appears in the Caribbean Sea at a time when the prevailing winds in that region are from the southeast the cyclone is carried more northward than when the winds are from the east and the cyclone comes under the influence of the westerly winds of the middle latitudes without being carried as far to the westward as is the case when east winds prevail, hence the cyclone recurves farther to the eastward when the southeast winds prevail than when the east winds prevail. The shifting of the prevailing winds in the Caribbean region from east to southeast as the hurricane season advances accounts for the fact that the mean paths of tropical cyclones show a progression to the eastward as the season advances.

The direction of movement of cirrus clouds over a wide area indicates the direction of movement of the general air current at their level. In the front and in the rear of the larger cyclones the cirrus clouds moved mainly forward in the same general direction as that in which the cyclone was traveling. This is shown by the charted directions of the clouds for six of the larger cyclones. The directions of cirrus clouds as recorded indicates that the general air currents in which the larger cyclones are traveling extend up to the level of these clouds and that these air currents carry the cyclones forward. Cirrus cloud directions observed in connection with the larger cyclones indicate that the depth of the air currents which carry the larger cyclones forward is at least five miles, while the width of the air current, as indicated by the width of the area covered by the cirrus belt, is at times more than 1000 miles.

In the smaller cyclones, those with a diameter less than 450 miles, the cirrus clouds both in the front and the rear of the cyclone frequently have a direction which carries them from left to right somewhat across the line of advance of the cyclone. In the front of the cyclone the cirrus are deflected to some extent in the line of advance of the cyclone but in the rear they

move mainly from left to right across the line of advanc
This indicates that the air currents in which the smaller cyclon
travel are not so deep and that in the cirrus stratum the pr
vailing west to east upper current in this region is not material
disturbed, except to some extent in the front of the small
cyclones, but moves on over the air currents in which the
smaller cyclones are traveling.

The depth of the prevailing air current in which the cyclo
travels is shown by the depth of the monsoonal winds as f
north as Groesbeck, Texas, and Broken Arrow, Okla., (24) whe
they often prevail in the summer months to a height of mo
than two miles. The trade winds over the Caribbean Sea a
their continuation as the summer monsoon curving to the nort
ward and eastward over the Gulf of Mexico are frequently
much greater depth than two miles, as indicated by the cirr
clouds moving forward in the line of advance of the larg
cyclones.

The courses followed by tropical cyclones are governed main
by air currents in the cloud regions, and therefore the pos
tions of high pressure areas sending out their anticyclonic circ
lation may materially influence the winds in neighborin
cyclones and the direction in which the cyclone advances.
this connection reference is made to Prof. Marvin's discussio
of steady motions of the winds within and between high and lo
pressure areas, where he shows the relation of winds to t
gradients. (12).

Sometimes high pressure areas augment the air current
which the cyclone is traveling and on the other hand, they ma
directly oppose and overcome this air current; in the latter ca
the cyclone ceases to advance and gradually fills up. The a
normal movement of the upper air currents in determining t
direction of movement of hurricanes is shown in the unusu
course followed by the tropical cyclone of September, 1919, (3
which has been carefully studied by Weightman.

6. The wind directions at the earth's surface, the directio
of the lower clouds, and the directions of the "alto-" clouds, gi
us definite information concerning what is taking place in t
regions within two miles above the earth's surface. The cirr
clouds show the direction of the air currents at their level a

rom the recorded directions of the lower clouds we can by nference draw deductions concerning what takes place in the yclonic area up to the cirrus level.

The cirrus clouds recorded in all of the cyclones show that here is no outflow of the air radiating in all directions from the ıpper part of the cyclonic area as would be required to satisfy he dumb-bell vortex theory. On the contrary the movements f cirrus clouds show that the air at their level moves on over he top of the cyclonic circulation in the larger cyclones with the ame general direction as that in which the cyclonic area is raveling; this indicates that the air current in which the *larger* yclone travels extends into the cirrus level.

The air current in which the *smaller* cyclone travels does not lways extend up into the cirrus level; this is evidenced by the act that cirrus clouds recorded during some of the smaller yclones followed to a great extent their prevailing directions or the latitudes where observed and moved from left to right ver the cyclonic area across the line along which the cyclone vas advancing. In other smaller cyclones the cirrus in front of he cyclone showed some inclination in the same general direc- ion as that in which the cyclone was advancing, but in the rear f these cyclones the cirrus have not been recorded with the ame direction as that in which the cyclone was traveling but noved across the rear following the prevailing direction of the irrus for the localities where observed. In cyclones which eased to advance the directions of the cirrus clouds, at times, vere opposed to the direction in which the cyclone was ad- ancing.

It appears that the air currents in which some of the smaller yclones traveled did not have sufficient depth to influence the irections of cirrus clouds either in the front or rear while in thers it affected the cirrus in the front of the cyclone, but not n its rear. The air which ascends, after the water vapor is con- erted into precipitation, is carried away in the prevailing upper ir current, to settle down to earth again in some distant region.

Dr. Doberck (9) in his studies of the "Storms in the Eastern Seas" reached the conclusion that "less than half a mile up in he air the incurvature of the winds towards the center dis- ppears in the average of the different quadrants but it still

blows in towards the center in the rear." We find the actu conditions prevailing above the earth's surface somewhat diffe ent from this conclusion reached by Dr. Doberck. In our stud the directions of the lower clouds show that there is no sy tematic incurvature of the winds in the front of the cyclon area at their level. The records we have, the most comple available, of the direction of the alto-cumulus and alto-stratu clouds show that the wind directions at their level in the fro of the cyclone are generally inclined slightly outward from th center instead of being inclined towards the center of the cyclon area. In the right rear quadrant we find the winds at all elev tions moving mainly in the same general direction as that which the cyclone is traveling instead of blowing in toward the center.

While the tendency to spiral incurvature around the cent is present the recorded facts show that this is materially mod fied in traveling cyclones. The recorded facts when proper charted show that the winds in traveling cyclones do not at a elevation have a spiral inward circulation around the cyclon center with uniform incurvature towards the center such usually has been represented, notwithstanding symmetry of is bars exists for a considerable distance from the center of th cyclone.

The wind directions, at the earth's surface, as related to th center and direction of movement of the cyclone, result fro a combination (a) of the forces (modified by resistance e countered) acting on the inflow of air towards the cyclon center, with (b) the air current in which the cyclone is travelin The combination of translation with rotation tends to bring th winds in the right rear quadrant into and keep them in th same general direction as that in which the cyclone itself traveling; in the right front quadrant the inclination of th winds towards the center is diminished and the directions acro the radius are more nearly at right angles; in the left half the cyclone the winds come around the center with increasi inclination towards the center as they pass through the rear a curve into and take up the direction of the winds of the rig rear quadrant.

A striking feature of the larger traveling cyclones is that *ov*

he right rear quadrant the winds at all elevations up to and argely including the cirrus level move forward in the same general direction as that in which the cyclone is traveling; this is hown on charts Figures 42, 48, and 49, by the directions of he winds at the earth's surface, the directions of the lower louds, the intermediate clouds, and as a rule, the upper clouds ver this quadrant. The momentum of the air current in which he cyclone is traveling combines with and augments the velocity f the winds in the right rear quadrant of the cyclone, and causes he sustained high velocities uniformly recorded in that part f the cyclonic area.

Distribution and Causes of Precipitation

7. Precipitation as it is occurring in traveling cyclones is not istributed around the cyclonic center as the rainfall shown long the path of the center after the passage of the cyclone night indicate, and as it is generally represented in contemorary works on meteorology. We find that very little precipiation occurs in the rear half of the traveling cyclones. The reatest precipitation intensity in the larger cyclones is found 0 to 80 miles in front of the cyclonic center and mostly to the ight of the line along which the center was advancing at the ime of its occurrence. In the smaller cyclones the greatest recipitation intensity is found not so far in advance of the enter as in the larger cyclones, but it is also in front of the enter and to the right of the line along which the center was dvancing. The precipitation distribution in cyclones moving hrough the Florida Straits is the same as in the cyclones that raveled from the Gulf into the interior. In all of the traveling yclones the precipitation almost ceased with the occurrence f the lowest barometer and very little precipitation occurred in ny part of the rear of the cyclonic area, whether traveling over ater through the Florida Straits or moving inland on the ulf Coast.

In the three cyclones which ceased to advance, on moving nland, the greatest hourly precipitation which had first occurred n the right front quadrant while the cyclone was advancing hifted to the rear of the cyclone as it stopped traveling and the

precipitation does not show systematic distribution such as found in the traveling cyclones.

8. The causes for the precipitation occurring mainly in t front half and very little in the rear half of traveling cyclon can not be explained as the results of the position of adjace land and water areas. In all three of the cyclones which mov through the Florida Straits and across the Florida Peninsu where the winds in all quadrants were almost continuously co ing off of large bodies of water, we find the same general d tribution of precipitation as related to the cyclonic center we find in the other traveling cyclones moving over land are Furthermore, in cyclones which ceased to advance the precip tation occurred in all parts of the cyclonic area and mostly the rear half, notwithstanding all three of these cyclones c cupied positions with regard to land and water areas the sa as that occupied by traveling cyclones in which the precipit tion was confined mostly to the right front quadrant and which there was no precipitation of consequence in the rear h of the cyclonic area. The position of the land and water are as related to the direction in which the cyclone is travel accounts for the *intensity of precipitation* in the cyclone, b *not for the distribution of the precipitation* over the cyclo area.

The temperatures in the different parts of tropical cyclon traveling through this region do not vary greatly, as shown Figures 51, 52, and 53. These show that we must look elsewhe than to surface temperature differences for the causes and d tribution of precipitation in tropical cyclones.

The mechanical and physical processes in these cyclones shown by wind directions and their convergence and resulta ascension of air masses within the cyclonic area will accou for the precipitation and its distribution and also for the greate precipitation intensity occurring in the same position as relat to the cyclonic center in all traveling cyclones.

9. We have already shown that the winds in the right re quadrant of the cyclone blow, with high velocities continuous during the life of the cyclone, in the same general direction that in which the cyclone advances. The winds in this quadra certainly play an important part in the causes and distributi

f precipitation in cyclones, and are the sources through which ne precipitation is supplied and from which the supply of nergy in the cyclone is derived. In the larger cyclones these inds constitute air streams at least five miles in depth, 250 to 00 miles in width, and 400 to 800 miles in length, extending the line of advance of the cyclonic area. In this connection eference is made to Figure 42 where the air stream is repre- nted by combining four of the larger traveling cyclones. The ngth of the air stream shown in this figure is 400 miles and it xtends back some 400 miles additional as part of the air current which the cyclone is traveling.

While the cyclonic area is traveling with a speed of 8 to 16 iles per hour the winds of the right rear quadrant of the yclonic area come into the right front quadrant with sustained elocities near the earth's surface (extending for some distance the rear of the center) of 80 to 100 miles per hour and veloci- es of 30 to 40 miles often prevail for a distance of more than 00 miles in the rear of the cyclonic center. These winds of igh velocity in the right rear quadrant come into convergence ith the winds in the right front quadrant as previously de- ribed. As a result of this convergence the moist air moving ver the surface in the winds coming through the right rear uadrant of the cyclone is forced to ascend in the right front uadrant of the cyclonic area and as it ascends is carried forward y its own momentum towards the front of the cyclone.

Shaw (1) in discussing the physical processes of weather efers to the momentum of air streams and says:

> "It suggests that the great streams of air, sometimes as much as 1000 miles broad, are from their own momentum, features of greater importance from the dynamic point of view than the positions of high and low pressure."

The momentum which the air streams in the right rear quad- ant of the cyclonic area receive from the high velocities pre- ailing over a long stretch in that part of the cyclonic area, auses them, when they come into convergence with winds in ne right front quadrant, to ascend through and mix with the inds which blow across the front of the cyclonic area. On

account of its momentum, this air stream from the rear co tinues to move forward after convergence more rapidly than t cyclone is traveling, and it ascends and moves on at increasi elevation in the right front quadrant of the cyclonic area. Th air stream, nearly saturated with moisture, expands and co dynamically as it ascends, and this causes the condensation a precipitation of the water vapor and the liberation of late heat, in the front and to the right of the line along which t center of the cyclonic area is advancing.

The latent heat released as the result of condensation retar the rate of cooling of the ascending saturated air, and therefo causes the temperature of the ascending air mass to be high at the elevation where condensation is taking place, than would have been if cooling had taken place at the adiabatic ra resulting from expansion not modified by the condensation aqueous vapor. The ascending air mass from which preci tation is falling therefore has a higher temperature than t surrounding air at corresponding elevations and this causes t ascent and rarefaction of the air mass to become more rap and further intensifies the condensation of moisture, and th augments and intensifies the precipitation directly under t region where the air mass is ascending most rapidly.

The region of greatest precipitation intensity is shown by t hourly amounts in brackets for the larger cyclones as chart on Figure 43, and for the smaller cyclones as charted on Fig 45. By comparing these with the wind directions on Figure for the larger cyclones and Figure 44 for the smaller cyclones is seen that the region of greatest precipitation intensity cyclones is 50 to 100 miles in front of the region where the wir of the right rear quadrant converge with those of the right fro quadrant.

From the foregoing the causes for the precipitation as fou in cyclones are summed up as follows: The convergence of t winds from the right rear quadrant with those of the rig front quadrant causes air to ascend; the momentum carries t ascending air mass forward into the front of the cyclonic ar expanding and cooling as it reaches higher levels; the vap of water in the nearly saturated air mass is rapidly condens giving excessive precipitation in the front and in the right fro

uadrant of the cyclonic area as found in the eleven traveling yclones studied.

Orographic Influences

10. The cyclone of August 15-22, 1915, crossed the United tates without any high pressure areas appearing during its assage to influence the precipitation in any part of the cyclone. Ve have in this instance a rare case where during a period of ve days and covering a distance of nearly 2000 miles (see igure 19) the precipitation in a tropical cyclone while traveling the middle latitudes was influenced only by the cyclonic circu- tion and orographic conditions.

Those parts of Texas over which the cyclone advanced are irly level and the precipitation there was cyclonic. While ie cyclone was traveling across Arkansas, in fact, from the me the cyclone moved out of northeastern Texas until it ached the central Mississippi Valley, the precipitation was fluenced more or less by orographic conditions, the cause and stribution of the precipitation being determined partly by ie mountains in western Arkansas and partly by the cyclonic rculation.

Much of the moisture carried up from the Gulf of Mexico in ie air stream coming up through the right rear quadrant of ie cyclone while it was traveling across Arkansas was precipi- ted under the influence of the mountains before the air stream ached the front of the cyclone. It is interesting to note that ie cyclone diminished in intensity while moving over the moun- ins in Arkansas and then regained intensity over the central Iississippi Valley where torrential rains occurred again in the ght front quadrant of the cyclone, almost as heavy as the ins which fell as the cyclone moved from the Gulf of Mexico to Texas.

While the cyclone was traveling over the central Mississippi alley there were no mountain ranges between the cyclonic rea and the Gulf of Mexico to elevate the air and precipitate ie moisture which was at that time being carried from the Gulf f Mexico by the winds of the right rear quadrant to the front f the cyclonic area. The moisture laden air from the Gulf f Mexico was carried over the level lands of the coastal plains

and up the Mississippi Valley encountering no elevated ar on its way to the front of the cyclonic area and the great condensation and precipitation intensity occurred here in front of the cyclone. The precipitation was distributed o the cyclonic area, while over the central Mississippi Valley, the same manner as when the cyclone was traveling over coastal plain of Texas, three days previously, and the same found in cyclones moving through the Florida Straits.

The extent to which small mountain ranges outside the cycl coming in between the right rear quadrant of the cyclonic a and the sources of moisture supply influences the rainfall in cyclonic area is shown in this cyclone. When the cyclone August 15-22, 1915, had advanced northeastward to the po where the air stream in the right rear quadrant of the cyclo coming first from the Gulf of Mexico and later from the Atla Ocean, was drawn over the Appalachian Plateau region, find that heavy rains occurred on the windward side of Appalachian Plateau and the precipitation in front of cyclonic area proper diminished steadily and proportionat as is shown on Map Figure 19. There was no increase in p cipitation in the left half of the cyclonic area as this cycl approached and moved over the Great Lakes.

When Cyclones Cease to Advance

11. The movements of the upper air currents as shown the clouds in cyclones which ceased to advance are materi different from those in cyclones which continued to travel ward. This is especially shown in the region of the cirrus clou In the cyclone of August 26-28, 1911, clouds of the cirrus c were observed at Charleston, S. C., at two levels at the sa time, and while of somewhat different directions, both w opposed to the line of advance of the cyclonic center; at Sav nah, Ga., the cirrus clouds were at first moving forward in front of the cyclone in the same direction as that in which center of the cyclone was traveling, but about 10 hours be the cyclonic center reached Savannah, the cirrus clouds sho a reversal of direction indicating that the air current at the l of these clouds had changed direction and was directly opp to the previous upper air movement at the cirrus level that region and also opposed to the direction in which the cycl

ad been advancing. The opposing current, as indicated by hese cloud movements, evidently extended down into the region f rain formation and forced the ascending mass of air from vhich precipitation was occurring, back over the cyclonic center. This is indicated by the fact that after the cirrus clouds showed direction opposed to that in which the cyclone was traveling, he precipitation instead of being found in the front was mostly n the rear of the cyclone and the cyclone ceased to advance.

In the cyclone of July 5-6, 1916, the cirrus clouds observed t New Orleans, La., in the front of the cyclone were mainly cross the line along which the cyclonic center was advancing nd the first cirrus observed at Mobile were somewhat opposed o the line of advance. In the rear of the cyclonic area the irrus observed at New Orleans were somewhat across and opposed to the line of advance. The precipitation occurred in his instance in all parts of the cyclonic area whereas in all of he cyclones which have traveled through this region and continued to advance the precipitation was confined mostly to the ront and very little occurred in the rear half of the cyclonic rea. The opposing current shown by the movement of cirrus louds which the cyclone of July 5-6, 1916, encountered in this egion was evidently of sufficient force to overcome the air urrent in which the cyclone had been traveling and extended own to the region of rain formation and shifted the rain area rom the front into the rear of the cyclone. The cyclone after his soon ceased to advance and died out over the interior of Alabama.

The cirrus clouds observed in front of the cyclone of July 2-16, 1916, at both Savannah, Ga., and Wilmington, N. C., were pposed to the line of advance of the cyclone. In the rear the irrus at Savannah, Ga., and Charleston, S. C., were somewhat cross and opposed to the line of advance. In this cyclone the reater part of the precipitation occurred in the rear of the enter of the cyclone; the advance of the air current in which he cyclone was traveling was checked by a counter-current vhich caused the ascending air stream, from which rain was alling, to shift backward over the rear of the cyclone. The yclone soon ceased to advance and died out over the Carolinas.

Professor Humphreys (11), in discussing the origin and maintenance of cyclones and regarding the seat of energy, says:

"From the above it is evident that the seat, so to spea of the tropical cyclone, is where the sustaining energy supplied, that is, where condensation is taking pla Hence, the movement of the air at this level, and not at t surface, determines the course of the storm and even carr it athwart shallow surface winds."

In cyclones which curved to the right, the greatest hou precipitation intensity is found farther to the right of the li along which the cyclonic center was advancing at the time t heaviest precipitation was recorded than in cyclones which a vanced along straight lines. The centers of the cyclones ha all moved towards the region of the greatest hourly precipitati intensity. A change in the position of the greatest precipitati intensity indicates that the cyclone is coming under the influen of an air current moving in a different direction from that wh previously had been carrying the cyclone forward. When t air current in which the cyclone is traveling encounters an o posing current in the upper air, the air stream coming up out the right rear quadrant of the cyclone and ascending the right front quadrant is carried backward over the cyclo center by the opposing or counter-current, the condensation a precipitation then takes place over any part or all parts of t cyclonic area, depending on the force and direction of t counter-current. The cyclonic area then drifts back and for the lowest pressure following the area of greatest precipitati intensity as shown in the three cyclones combined.

Continuous Re-development of the Cyclone Over Ar of Greatest Precipitation Intensity

12. The liberation of latent heat resulting from the co densation of moisture in the ascending air mass is greatest o the region of greatest precipitation intensity, consequently, already explained, the air over the region of greatest precipi tion intensity ascends much more rapidly than the air outs where the precipitation is less. The air moves in from vario directions towards the depression caused by the ascending a the deflective force of the earth's rotation comes into play, a the center of the cyclonic action is continuously renewed w

new systems of rotation forming over the area of greatest precipitation intensity.

The area of lowest pressure at the earth's surface, in the traveling tropical cyclone, occurs to the rear of the area over which the greatest condensation and precipitation takes place. There is no question but that the center of energy in the cyclone and the center of the cyclonic action is continually renewed in the cloud strata over the region of greatest precipitation intensity and the occurrence of the lowest pressure at the earth's surface is to the rear of the center of action and release of energy in the cloud region.

The core of the cyclone is inclined from the low barometer at the earth's surface forward into the cloud region over the area of greatest precipitation as is indicated by the movement of the area of lowest pressure at the earth's surface towards the region of greatest precipitation intensity.

Shaw (42) in discussing convection in cyclones describes the manner in which rotating motion will extend downwards to the earth's surface and in conclusion says:

> "Hence we may conclude that the core of a column descending to the surface will not be along a vertical line but to a point on the surface displaced from the vertical across the wind of the lower layers."

The fact that precipitation almost ceases with the occurrence of the lowest barometer, and that there is only light precipitation in the rear half of the traveling cyclones shows that there is very little ascending air in the region of or in the rear of the lowest barometer at the earth's surface.

The energy of the cyclone is released and comes into action in the region of greatest condensation and precipitation intensity but the air stream in the right rear quadrant of the cyclonic area, which moves forward continuously in the line of advance of the cyclonic area, is the real source which supplies the material from which the energy is produced. Through this air stream the traveling cyclone may draw its moisture supply from regions sometimes as far as 600 to 1000 miles to the rear of the cyclonic center.

When the tropical cyclone of August 15-22, 1915, was centered

over eastern Missouri, in extra-tropical regions, the moistu supply from which it produced the torrential rains which f in the front and the right front quadrant to the right of t line along which the center was advancing, over southeaste Missouri, northeastern Arkansas, and central Illinois, had be brought up over the comparatively level lands of the Mississip Valley from the Gulf of Mexico 600 miles in the rear of t cyclonic center. The cyclone at this time was much nearer the Great Lakes than to the Gulf of Mexico, and notwithstan ing the left half of the cyclone was approaching and travel onward directly over the Great Lakes there was no increase the precipitation in the left half of the cyclonic area.

It is a fact worthy of note that as the left half of the cyclo approached and moved over the Great Lakes, the precipitati in this half of the cyclone fell off proportionately to the decrea in the right half. After the cyclone crossed the Mississip River, the Appalachian Plateau came between the cyclonic ar and the Gulf of Mexico and the Atlantic Ocean and cut off portion of the moisture supply from the cyclonic area by p cipitating it on the windward side of the Plateau. Map Figu 19 shows the extent to which the Appalachian Plateau caus on its windward side, the precipitation of part of the moistu being carried from the Gulf of Mexico and the Atlantic Oce towards the front of the cyclone by the air stream in the rig rear quadrant of the cyclonic area.

Origin and Development of Tropical Cyclones

13. The records we have show that cyclones moving throu the Gulf and South Atlantic regions have nearly circular isoba low barometer and a calm or little wind at the center, torrent rains, and high wind velocities, the same as are found in cyclo traveling through the tropical regions, and the wind directi in the cyclonic area are similar to those found by Hall (40) cyclones in the Caribbean Sea: and tentatively, until disprov if not true, it may be inferred that the conditions of pressu wind, and precipitation found in these cyclones in the Gulf a South Atlantic regions are in the main the same as those wh prevail in the cyclones in the tropics. From what we find these cyclones we also infer that tropical cyclones do not di

n their development from that of extra-tropical cyclones, except as modified by the influences of latitude and the differences in the moisture in the regions where the cyclonic development takes place.

Humphreys (11), in discussing tropical hurricanes says:

> "The physical causes of these storms, if they originate as seems probable, in the doldrums and between the counter-trades or similar winds, appears to be partly thermal and partly mechanical, and their subsequent maintenance, after reaching the middle and higher latitudes, the same (largely mechanical) as that of any other cyclone of the same place."

We have in our study a series of cyclones the greater number of which, during the last twenty-five years, have moved from the tropics and thence northward across the United States. When in the tropical regions they are tropical in character, but in the middle latitudes they are extra-tropical, the same cyclone adapting itself to the regions through which it is traveling. The principal differences between these cyclones while in the tropics and in the middle latitudes are differences in intensity which are determined partly by latitude effect and to a greater degree by differences in the amount of water vapor supplied. Differences in the temperatures of the tropical regions as compared with those of middle latitudes even over bodies of water accounts to a great extent for the difference in the energy of cyclones in the two regions.

The mean temperature in the tropics during the hurricane season is about 80°, and at this temperature the air can contain 11 grains of vapor of water per cubic foot. The average temperature of the great storm tracks in the North Atlantic is about 55°, and a cubic foot of air at this temperature can contain only 5 grains of water vapor. A reduction of temperature amounting to 25° in an ascending saturated air mass, from 80° to 55°, in the tropics, would precipitate 6 grains of water vapor from each cubic foot of air; while a 25° reduction in the temperature of a saturated air mass, from 55° to 30°, in the North Atlantic, would precipitate only 3 grains of water vapor from each cubic foot of air. With the same fall in temperature the amount of precipitation in the tropical region would be twice that of the

North Atlantic region. The difference in temperature governin the amount of moisture supplied in the two regions combine with the latitude effect accounts for the observed difference i intensity of the tropical cyclone in tropical and extra-tropic regions.

The mechanical forces acting in these cyclones must neces sarily be of the same nature both in the tropics and the middl latitudes, but modified by latitude effect, topography, and th position and intensity of high pressure areas in the neighbo hood of the cyclone.

The development of tropical cyclones, it appears, may b brought about by large air currents running into the doldrum the convergence of counter currents on the border of the trad winds, or currents moving in the same direction with differen velocities which develop ascending air streams. The relativ positions of the air currents are factors in determining the de velopment and progressive movement of the cyclones. Thes air currents may be originated by differences in the therm conditions of large masses of air or by an unequal distributio of pressure the seat of which may be far away from the regio where the convergence of air streams takes place.

Algue, (10) in his studies of "The Cyclones of the Far East has expressed the opinion that many of the cyclones in th China Sea are originated by opposing currents. Doberck (9 and others who have studied tropical cyclones on the groun hold the same view.

The air currents which converge and cause the air to ascen may be functioning in the upper air over the doldrums or on th border of the trade winds, and may not always extend to th earth's surface. Where we have the convergence of air curren and the resultant ascending air stream cooling as it ascends, th liberation of latent heat, resulting from the continuous and ex cessive condensation and precipitation of water vapor, ene getically keeps up the rarefaction of the air over the area c condensation and precipitation; the air moves in from variou directions towards the area where convection is taking plac and when at a sufficient distance from the equator the deflectiv force of the earth's rotation acts on this inflowing air and w have the cyclonic development in action. The convergence c

he winds in the cyclonic area then sets in at the earth's surface, s found to exist in the cyclones charted in this study.

Once the cyclonic movement is started the air current in vhich the cyclone is traveling (the trade winds in the tropics) vill continue it in action after the primary cause has ceased to xist. This air current carries the newly developed cyclone orward, brings the winds of the right rear quadrant into the ine of advance of the cyclone and their convergence with the vinds in the right front quadrant of the cyclonic area keeps up he ascending air stream in which the condensation and precipi- ation is taking place. This ascending air stream is carried for- vard by momentum into the front of the cyclonic area and is ttended by condensation and precipitation as we have found n the same cyclones in the Gulf and South Atlantic regions. The cyclone when once started is continued in action in this nanner by the action of the air current in which the cyclone s traveling. The course which the cyclone follows is determined y the course and direction of the trade winds over the Carib- ean Sea, the summer monsoonal winds over the Gulf of Mexico and finally by the winds of the middle latitudes except vhen there are abnormal movements of the upper air currents vhich overcome the regular air currents and cause the cyclones o follow abnormal courses or die out, as shown in the case of he cyclones which ceased to advance.

Sir Oliver Lodge (38) in referring to the energy of cyclones ays:

> "I do not find that people in general are aware of an important source of energy for the maintenance and intensification of cyclones, nor am I acquainted with a clear exposition by a meteorologist that the condensation of aqueous vapor will suffice.
>
> "Atmospheric pressure being a ton per square foot, the disappearance or collapse of a cubic foot of ordinary air would yield a foot-ton of work. The disappearance, by complete condensation, of the aqueous vapor in 760/12.7, say 60, cubic feet of atmosphere would yield about the same amount.
>
> "If then, the temperature of the saturated air fell from 18° to 12° C., by reason of condensation and rainfall, so

that the vapor pressure diminished from 15.36 to 10.4 millimeters of mercury, a foot-ton would be generated i each 155 cubic feet of that region of atmosphere. Inc dentally, the corresponding deposit of the liquid would b 5 grams per cubic meter, or a rainfall of one-third inch fro a vertical mile of air.

"Assuming that the above fall of temperature in the cer tral region of a traveling cyclone is not excessive, the energ available in each cubic mile of it would be nearly a thousan million foot-tons."

The *energy is not released in the central region* of the tropic cyclone as assumed by Lodge, but is released in the front an right front quadrant of these traveling cyclones.

The hourly precipitation in the larger cyclones, as shown c Figure 43, exceeds one-third of an inch over an area 100 mil wide and 250 miles in length, 25,000 square miles of area exten ing across the front and mostly in the right front quadrant the cyclonic area. Half an inch to more than one inch fal in one hour over an area 50 miles wide and 150 miles lon 7,500 square miles of area extending from the line of advance the center across the cyclone in the right front quadrant. Th rain area is continuous while the cyclone advances, and con mences 100 to 125 miles in front of the lowest barometer an is greatest about 80 miles in front of and 6 hours before th occurrence of the lowest barometer. In front of the line advance of the center and for 150 miles to the right of that lin the total precipitation which occurs during the passage of th front half of the cyclone ranges at many stations from 7 inch to 16 inches, or more in some cases, in 12 to 14 hours.

From the precipitation shown in the cyclones charted, w get some conception of the enormous amount of energy releas and operating in the right front quadrant and directly in fro of the traveling cyclone. There is ample energy released he to account for the continuous redevelopment of cyclones of th greatest intensity and to account for many of the observed ph nomena attending such cyclones.

The energy supplied by the condensation and precipitation moisture and release of latent heat in the ascending air strea in front of the cyclonic area does not of itself carry the cyclo

orward, but does determine the pressure minimum, the steepness of the barometric gradients, and the wind velocities in the yclone, in short, the destructive forces of the cyclone. Furthermore, the position of the area of greatest precipitation intensity s indicative of the vigor of the carrying current; the greatest ourly precipitation intensity is well to the front only in traveling cyclones, and cyclones moving slowly or changing direction now a change in the position of the heaviest precipitation area orresponding to the changes taking place in the carrying air urrent. Of course, precipitation is evidence of the carrying urrent only when the cyclone is traveling over regions free rom mountains, *i. e.,* where the precipitation is cyclonic and not rographic. It appears from the evidence at hand that the epth and width of the air current in which the cyclone exists nd which carries the cyclone forward has much to do with determining the size and extent of the cyclone.

We have noted that the cirrus clouds both in the front and in he rear of all the larger traveling cyclones have moved forward ith a strong component directly in the line of advance of the yclonic center and this shows that the air currents in which he large cyclones exist extend to the level of these clouds. he cirrus clouds in the smaller traveling cyclones have a movement in the front somewhat in the line of advance but across hat line, while in the rear the direction of the cirrus is more irectly across the line of the advance of the cyclone. This hows that the current in which the cirrus clouds are observed tains its west to east component in this region over the smaller yclones and therefore the current in which these smaller yclones exist does not extend into the cirrus region. In the rger cyclones this west to east component of the cirrus in this gion is changed by the greater depths of the air currents in hich the larger cyclones are traveling as is shown by the cirrus oth in front and rear of the cyclone moving in the direction in hich the cyclone is traveling.

The intensity of the cyclone depends on the position and nount of moisture supply as related to the center and direction movement of the cyclone. The distance over which a cyclone ill draw its moisture supply depends on the size of the cyclone nd the length of the air stream in the right rear quadrant oving forward in the line of advance of the cyclone. The

moisture supply may be curtailed, not only by distance fr water areas, but when the air stream in the right rear quadra which carries the moisture, is drawn up over elevated regio causing the precipitation of the moisture before the air reac the cyclonic area, or by changes in the direction of moveme of the cyclonic area which cause the air stream in the right re quadrant to come off land areas instead of off the water.

Counter or opposing upper air currents sometimes neutral each other and the current in which the cyclone is being carri forward fails; in such cases the area of precipitation is thro backward and occurs over the entire cyclonic area, then t cyclone gradually fills up and dies out. Or, on the other ha one air current completely overcomes the other, carries the cending air stream, from which precipitation is occurring, another direction, then the cyclone re-develops and travels the direction determined by the stronger air current. T backing of cyclones and loops in paths of cyclones are caus by changes in the direction of the movements of the air curre at some distance above the earth's surface. Air currents abo the earth's surface determine the location of precipitation related to the cyclonic center and the resultant direction in wh the cyclone travels.

The area of lowest pressure at the earth's surface mo towards the locality where the precipitation intensity is m marked, which as previously noted is the result of the for which carry the cyclone forward. When the greatest precipi tion intensity is far in advance of the cyclonic center the cyclo travels with greater speed than when the greatest precipitati intensity is near the center. When precipitation of any con quence is occurring in the rear of the cyclonic center the cyclo travels slowly and if the greatest precipitation intensity occ in the rear of the cyclonic center the disturbance will die out move backward. Sometimes cyclones move off in another dir tion, after lingering for a few days and at times loops in t paths are formed in such movement.

In concluding this paper I desire to express appreciation assistance rendered by Mr. R. A. Dyke and Mr. W. F. McDon in the way of suggestions and references, and to Mr. McDon especially for assistance in the preparation of charts, ma and figures.

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APPENDIX A

Relation of Changes in Storm Tides on the Coa of the Gulf of Mexico to the Center and Movement of Hurricanes.

APPENDIX "A"

Relation of Changes in Storm Tides on the Coast of the Gulf of Mexico to the Center and Movement of Hurricanes

SYNOPSIS.

A brief summary of what is known bearing directly on this subject concerning wind and waves is given.

Hurricanes are in all instances preceded by storm tides. The water commences rising on the coast in front of the cyclonic area, one to two days before the storm is experienced.

The wind velocities and directions in different parts of the hurricane, as deduced theoretically, do not meet the requirements in this study to explain the rises in tides. Composite charts showing the actual wind directions and velocities determined from stations in the different parts of the cyclonic area are submitted. In the right-hand rear quadrant the winds blow with much greater velocity and persist in the same direction longer than in any other part of the hurricane. At stations in this quadrant the wind has been found to blow for 24 hours or longer with a direction in line with the advance of the hurricane, with an average velocity of 60 miles per hour, and for 13 hours at 70 to 85 miles per hour. In other parts of the cyclonic area the wind continues to blow over the water in the same direction for only a few hours.

Winds in the cyclonic area over water develop waves of a size and length which bear a relation to the sustained velocity of the wind and the length of time the waves are under the influence of the same wind direction. Waves of different sizes are developed in proportion to the winds which prevail in the different parts of the cyclonic area. The largest and longest waves are created in the rear right-hand quadrant; these waves pass on through the cyclonic area and move to shore where they cause a rise in the water in the front of and on the right of the line over which the center of the hurricane is advancing. This rise begins when the center of the hurricane is 300 to 500 miles distant, and continues until the hurricane moves inland. The heights of the water reached at shore near the center of the storm vary from 8 to 15 feet above mean Gulf level.

Changes in the position of the rise of the storm tide indicate changes in the course of the storm.

Italic figures in parentheses refer to authorities preceded by the same figure in the bibliography at the end of this paper.

Storm Waves and Swells

Waves and tides that appear along our coasts, many hours and at times one or two days in advance of hurricanes, convey some definite information regarding the position and direction of movement of the storm still many miles distant in the Gulf. Swells and waves break upon the shore and the water rises as the result of winds prevailing in the Gulf sometimes 400 to 500 miles distant.

The relations which the movements and actions of the waves and tides bear to the position and movement of the meteoro-

logical disturbances, which develop and carry these phenome to shore, have not received the attention the importance of subject justifies.

Ocean waves and their action under winds have received attention of investigators, and we will summarize briefly more important results obtained that bear directly on this su ject. Their height, length, and speed have been carefully stud and recorded in both deep and shallow water. In the Atlan and other oceans with 600 to 1,000 miles sea room it has be found in ordinary storms that waves of 35 to 40 feet in hei are developed and in exceptional storms waves may exceed feet. The crossing of two large waves will sometimes send up peak of water which has been estimated to be 50 to 55 feet height. The quotient obtained by dividing the wind veloc in miles per hour by 2.05 represents the average height in feet the waves developed by that wind; however, this average will exceeded when the wind has full opportunity to exert its for Waves produced upon the deep sea communicate their moti to the water to a depth of about one-fourth the wave leng when the waves run into water which has depth less than o fourth the wave length a reduction of the speed of the wa results and continues as shallower water is reached; the dim ishing speed causes the wave crests to close up, the space se arating them becomes less and less as the depth of the wa diminishes; but the interval of time between the arrival at sh of successive crests remains unchanged. The average storm wa in deep water moves forward with a velocity a few miles hour less than the wind velocity that produces it. Long wa and swells that move through the storm and break upon shore travel when in deep water with a greater speed than highest waves in storms travel. In seas partly inclosed speed and length of waves are less than on the open ocean, th being determined by the length of fetch as well as winds.

In the Gulf of Mexico there is a distance or length of fe over deep water for 600 miles from the Yucatan Channel to middle Gulf coast and 800 miles to the west Gulf coast. Fr the Florida Straits to the middle and west Gulf coast the distan or length of fetch ranges from 600 to 1,000 miles.

In a cyclonic area with a progressive movement of 12 to

miles per hour large waves of considerable length are driven through and beyond the cyclonic area and by gravity and inertia are carried on far in advance of the area covered by the cyclonic circulation.

In discussing the propagation of waves of the sea in this connection Cornish says: (*6*)

> The breakers which arrive (at shore) somewhat irregularly during storms do so at intervals which, as far as I have noticed them, do not differ much from the intervals observed on board ship in the deep sea during storms. When waves are driven outside the wind area and left to themselves to travel over considerable distances the originally complex and irregular waves are analyzed into a series of simple, regular waves of graduated lengths. The longer and swifter are in front, the shorter and slower in the rear; the shorter components flatten out very quickly as they travel, whereas the longer components preserve their height with but little diminution for long distances and reach places far distant from the windward shore, where the water will heave with a long period undulation. At a considerable distance from the windward shore the state attained by the sea during a storm does not depend only on what the wind does there but by the transmission by gravity, independently of the wind of the longer-period component of the irregular waves which the storm has created to windward. The greater the length of the fetch the greater is the distance from which the surface water draws the reinforcement of its long period heaving and the greater, therefore, is that part of the wave disturbance which is of greater wave length than the dominant wave.

Darwin says, (*2*)

> The point we have to note is that an isolated disturbance will generate long waves and they will run ahead of the small ones; the long waves are more persistent, * * * but I do not understand how it is that the separation of the long from the short waves is so complete nor what governs the length of the wave.

Dr. George Stokes showed nearly half a century ago that ther is a transfer of water in the direction in which the wave is mov ing. The speed of the transfer depends on the depth and dimin ishes rapidly as the depth of the water increases. (*4*)

Coast currents observed as resulting from cyclonic storms i the Bay of Bengal have a steady set or drift to the west. Elio says: (*1*)

> It is probable that the strength of a cyclone advancing t the northward coast of the bay could be roughly ascertaine by the strength of the westerly set at the head of the bay Data are, however, wanting to test this. * * * The drif near the center of large storms in the Bay of Bengal may b so much as 6 to 8 knots * * *.

Observations of construction engineers indicate that the effec of waves on such structures as rubble breakwaters are generall not appreciable beyond a depth of 15 to 16 feet below the wate surface. This varies, however, in different localities. At Por Elizabeth, South Africa, blocks of rubble stone weighing 100 t 150 pounds, in 22 feet of water, were not disturbed by waves 1 to 20 feet high. At Colombo stones weighing three tons, in wate 10 to 14 feet deep, were disturbed by waves not exceeding 1 feet in height. At Algiers, Africa, stones 33 to 39 feet below th surface of the water were moved by waves or currents. (*7*)

The most destructive element in hurricanes is the breakin wave. A cubic yard of water weighs about 1,500 pounds and th waves, driven by the wind, break on the coast with the wate moving forward at a speed of many feet per second, and caus destruction which exceeds description.

Tide Records

The Port Eads tide gage is about 2½ miles up the South Pas from the Gulf, and the Burrwood gage in Southwest Pass is miles from the Gulf.

The tide gage at Galveston is at the foot of Twentieth Stree The tide records used with the Mobile (Ala.) meteorologic records are Pascagoula, Miss., 1909, and for the other year Fort Morgan, Ala.

Mean low water at Port Eads, La., is 0.3 of a foot and a

Burrwood, La., is 0.7 of a foot above mean Gulf level. At Fort Morgan, Ala., mean low water is 0.3 of a foot above mean Gulf level. For Galveston the United States Coast and Geodetic Survey gives mean low water (1917) 0.5 a foot below mean Gulf level.

The zero of the tide gage at Port Eads, La., is 3.16 feet and at Burrwood, 2.26 feet below mean Gulf level, and at Fort Morgan, Ala., the zero of the tide gage is 1.22 feet below mean Gulf level; therefore, mean low water on the Port Eads gage reads 3.46, on the Burrwood gage 2.96 and on the Fort Morgan gage, 1.52.

Darwin, in speaking of tides, says: (*2*) "The word 'tidal' should only be used when we are referring to regular and persistent alternations of rise and fall of sea level." He suggests that changes of water level due to wind and other atmospheric influences should be referred to as a "meteorological tide." The meteorological tide may be either low water or high water.

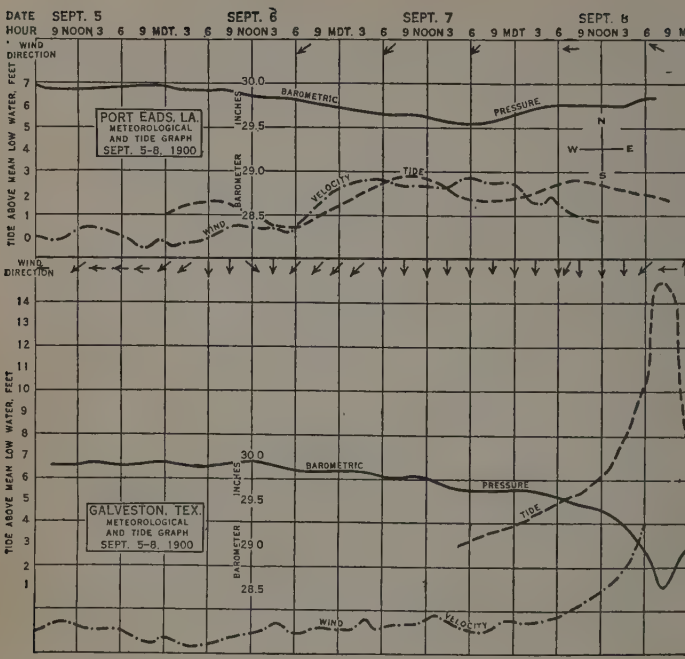
In referring to tides generally, mean low water as used by the United States Coast and Geodetic Survey will be used as the reference plane. The tide graphs shown with the graphs of meteorological conditions will give the tides above mean low water, in order that the records for Galveston, Burrwood, and Mobile, may be easily compared as the cyclonic area advances.

The term "Storm tide" will be used to represent the height of the water in excess of the predicted tide at a given hour. A study of the relationship existing between hurricanes and tides has been made possible through the complete records of tide conditions which we have had the good fortune to secure for this study.

Each hurricane, during the 20 years, 1900 to 1919, inclusive, will be taken up in chronological order, and we will deal especially with the relation of the tides to the center and movement of the hurricane.

Meteorological Records and Hurricane Tides

September 1-12, 1900.—This disturbance reached the Florida Straits, September 5, and moved in a northwesterly direction across the Gulf, a distance of nearly 1,000 miles, with its center passing inland over the western part of Galveston Island about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SEPT. 5-8, 1900

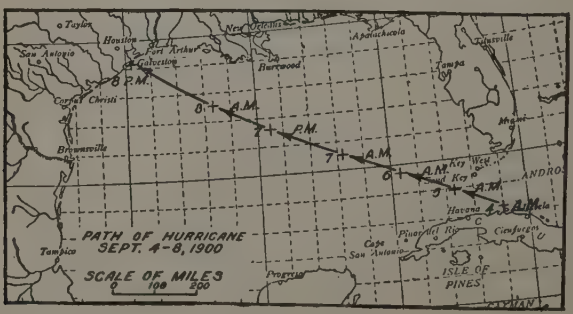


PLATE I.—*I. M. Cline.*

9 p. m., September 8. A graphical representation of the wind, barometric pressure, and tides at Port Eads, La., and Galveston, Tex., during the passage of this storm through the Gulf is shown in Plate I. At Port Eads the barometer commenced falling on the morning of the 6th and fell steadily until the night of the 7th, when 29.56 was recorded at the 8 p. m. observation. The wind was from the northeast during the 6th and until 8 a. m. of the 7th, with steadily increasing velocity, but not exceeding 44 miles per hour. The wind shifted to the east in the afternoon of the 7th, and the highest hourly velocity was 47 miles at 4 p. m. and 5 p. m. At 8 a. m. the wind was from the southeast and the velocity 30 miles per hour.

The tide gage at Port Eads showed a slight rise in the water above the regular tides during the 6th, and the water continued to rise steadily, reaching 2.8 feet above mean low water at 9 p. m. on the 7th, the rise caused by the hurricane in 24 hours being 1.2 feet. The oscillations of the regular tides were not overcome, but the water at lowest tide on the afternoon of the 7th was 1.6 feet higher than the lowest water on the previous day. Port Eads was about 150 miles to the right of the line of advance of the center of the hurricane at the time of the highest water. In this instance the water at shore commenced rising at Port Eads 150 miles to the right of the line of advance of the hurricane, when the center was 400 miles distant and 36 hours before that place was on a line drawn through the center of the hurricane at right angles to the line of advance. The highest water occurred with the passage of the center of the cyclonic area and coincident with the lowest barometer and highest winds.

At Galveston the barometer commenced falling at 5 p. m. on the 6th and continued falling steadily, but slowly, up to noon of the 8th, when it read 29.42 inches. The barometer then fell rapidly, recording 28.48 inches at 8.30 p. m. of the 8th, the lowest pressure recorded up to that time at a Weather Bureau station. The wind blew steadily from the north from noon of the 6th until 3 p. m. of the 8th, except that it blew from the northeast during the hours ending at 9 a. m. and 10 a. m. of the 8th. The prevailing wind was from the northeast from 3 p. m. to 8.30 p. m., September 8; east from 8.30 p. m. to 10 p. m., southeast from 10 p. m. to 11 p. m., and after that time from the south.

The wind velocity was less than 20 miles per hour up to 6 a. m of the 8th, after which the velocity increased steadily, reachin 30 miles per hour at noon of the 8th, and was 60 miles durin the hour ending 6 p. m. when the anemometer blew away. Th velocity was increasing rapidly at that hour, 2 miles having bee recorded at the rate of 100 miles per hour. It is estimated tha a velocity of 120 miles per hour was reached about the time o the shift of the wind to the east.

There are no tide observations at Galveston prior to 4 p. m of the 7th, when the water already stood 3 feet above mean lo tide, showing nearly 2 feet of storm tide. At this time the cente of the hurricane was 300 miles distant in space and 30 hours i time, and its line of advance was toward Galveston. The wate stood one foot higher at Galveston at this hour than at Po Eads, which was only about 175 miles distant, from the cyclon center, to the right of the line over which it was advancin The crest of high water at Port Eads was 2.8 feet, and wa reached at 9 p. m. of the 7th.

The water continued to rise rapidly at Galveston, and wa 8 feet at 3 p. m. of the 8th, notwithstanding there had been u to this time a prevailing offshore north wind of 20 to 40 mile per hour; such winds ordinarily give a tide below low wate After 3 p. m. of the 8th, when the wind shifted to northeast an east the tide rose with phenomenal rapidity, reaching 15 fe at 8 to 9 p. m., a rise of 1.4 feet per hour. The rapid rise durin the last five hours is attributed to the effects of the offsho north winds prior to 3 p. m. having retarded the rise in th water as the storm approached, by forcing it back and banking toward the storm center, and when the wind changed to north east and east this water was forced in rapidly with favorab winds. The rise in the storm tide was not noticeable on th coast 50 miles to the left of the line of advance of the hurrican

The destruction of property by the winds and waves in th hurricane amounted to about $30,000,000 and 6,000 persons wer drowned.

July 5-10, 1901.—A storm of small extent and moderate in tensity moved through the Yucatan Channel into the Gulf o Mexico on the 7th and reached the Texas coast west of Galves ton on the 10th. This disturbance gave a rise in water at Ga

veston of 4.5 feet at 3.30 a. m. No tide records of this disturbance are available. No damage of consequence resulted.

August 9-15, 1901.—This disturbance first appeared to the north of Cuba on August 9. It moved across southern Florida and into the Gulf of Mexico on the morning of the 11th, continued its course westward until the 90th meridian was reached, when, during the 14th, it recurved and on the morning of the 15th passed northeastward between New Orleans and Port Eads. This disturbance was of small diameter, but of considerable intensity. Its course was unusual.

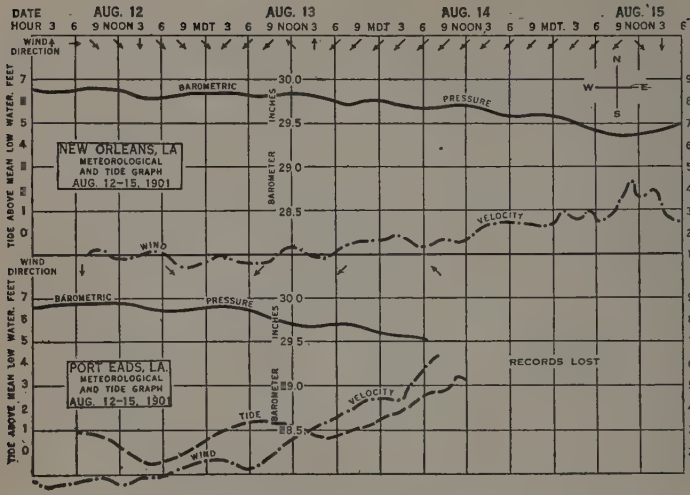
The barometer at Port Eads fell steadily, commencing about noon on the 12th and was 29.50 at 8 a. m. on the 14th, when the last observation was taken. The wind direction was northwest on the afternoon of the 12th and was northeast during the 13th; on the morning of the 14th it was southeast. The velocity increased steadily after 6 a. m. of the 13th, and was 62 miles per hour at 5 a. m. on the 14th, when the record was lost. The wind and pressure records at New Orleans are shown on Plate II, along with the wind, pressure, and tide records at Port Eads. (We have no automatic tide record for Mobile and Galveston for this storm.) The highest wind velocity, 40 miles per hour at New Orleans, occurred at 11 a. m. on the 15th.

Tide records at Port Eads show the water rising before midnight on the 12th when the center of the storm was about 200 miles distant. The water reached a height of 3.2 feet above mean low water at 11 a. m. on the 14th, the record after that time being lost. The Mississippi River at New Orleans rose from 5.9 feet to 11.4 feet on the morning of the 15th, the water forced up the river by the hurricane winds amounting to 5.5 feet

At Mobile the water was driven in and was awash of the wharves from 12 noon to 1 p. m. of the 14th. At 10 a. m. of the 15th the water began to come over the wharves, rising at the rate of nearly 1 foot per hour until 3.30 p. m., when it was 5 feet over the wharves and 8 2 feet above mean low tide.

Ten persons were drowned and the damage caused by the storm was $1,000,000.

September 23-27, 1906.—This disturbance passed through the Yucatan Channel on the morning of the 24th, traveled in nearly a straight line, and moved in on the Mississippi coast on the



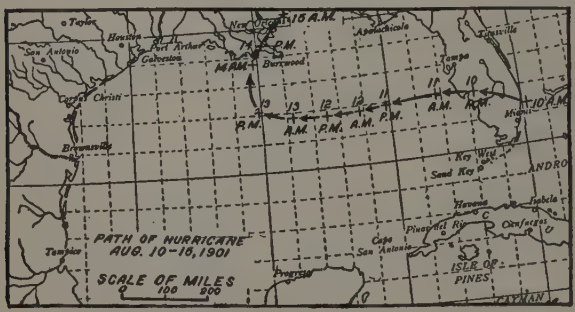
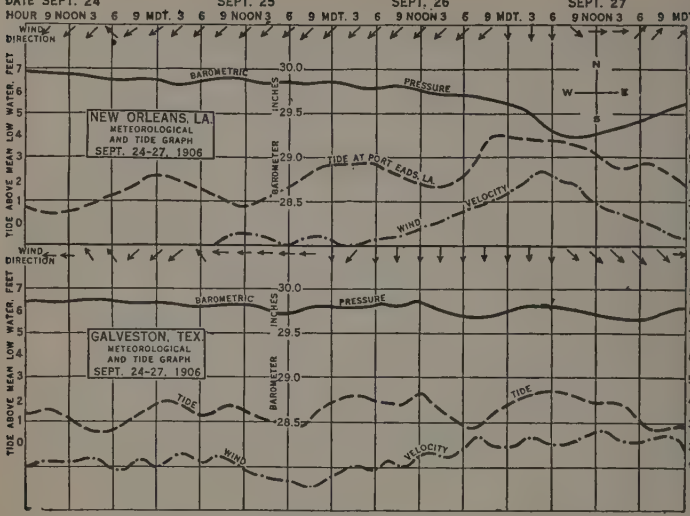


PLATE II.—*I. M. Cline.*

morning of the 27th. The tide records at Port Eads, charted with the wind and pressure records of New Orleans (Port Eads meteorological records being missing) and the Galveston pressure, wind, and tide records during the storm are shown on Plate III. This was a hurricane of large extent and unusual intensity. The tide at Galveston during the passage of this disturbance through the Gulf showed only normal changes. At Port Eads, 50 miles to the left of the line of advance of the center of the storm, the storm tide commenced rising during the afternoon of the 25th, when the hurricane was 250 miles distant in space and 28 hours in time. The rise in water shown at Port Eads on the afternoon of the 25th must have started from the southeast Gulf during the afternoon of the 24th and traveled, during 20 hours, a distance of more than 500 miles, at the rate of about 25 miles per hour. The cyclonic area advanced at the rate of about 10 miles per hour. The highest tide at Port Eads was 3.8 feet at midnight of the 26th. There was 3-foot rise in the river at New Orleans on the morning of the 27th as a result of the hurricane. Mobile and Pensacola were situated in the eastern segment of the cyclonic area, where they experienced the severest part of the hurricane. Both places reported the severest hurricane in their history. Unfortunately, we have no automatic tide records for either Mobile or Pensacola during this hurricane. The United States engineers at Fort Barancas on the bay below Pensacola, give the extreme storm tide at that place, 10.8 feet. At Mobile, the water was 9.9 feet above mean low tide. Thus we have the highest water at Port Eads, 50 miles to the left of the line of advance of the center of the hurricane, 3.8 feet, and at Pensacola, 100 miles to the right, 10.8 feet.

The damage from the hurricane at Pensacola was $2,120,000, and in the vicinity of Mobile, $1,850,000. The total known deaths at Pensacola were 32, and in the vicinity of Mobile 31 persons lost their lives.

July 18-21, 1909.—This disturbance moved from the Caribbean Sea through the Yucatan Channel on the 18th and moved inland on the Texas coast with its center near Velasco. The cyclonic area was about 100 miles in diameter and no hurricane winds attended it. High waves, swells, and tides prevailed as



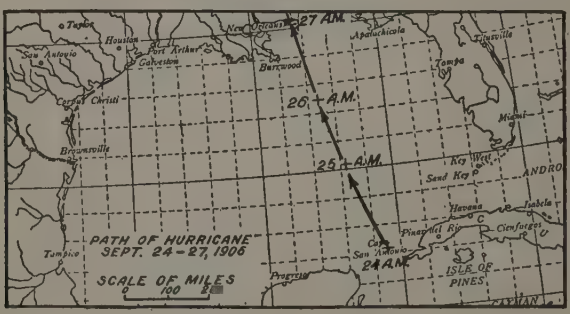


PLATE III.—*I. M. Cline.*

far to the right of the center as Galveston. We have no tide records for this storm.

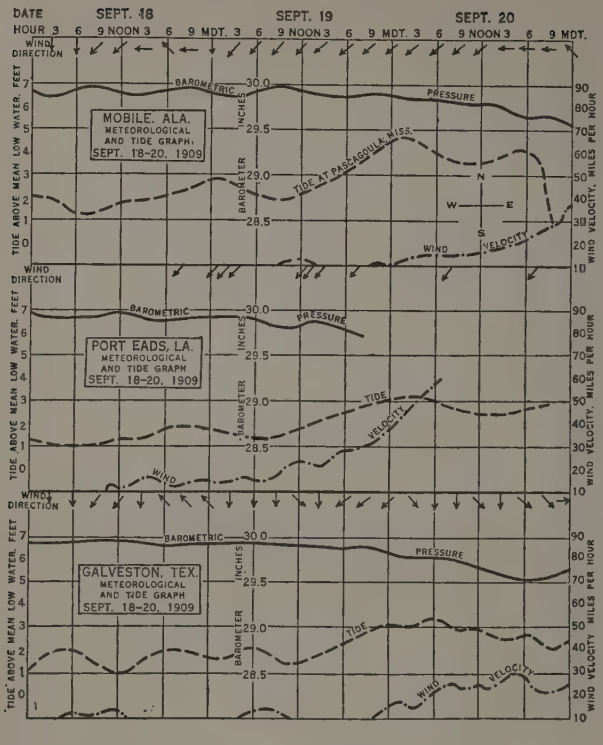
The damage to property amounted to $100,000 and 4 lives were lost.

September 12-21, 1909.—This was a storm of great intensity and of large extent, its effects being distinctly felt from east of Pensacola, Fla., to the west of Galveston, Tex. The disturbance passed through the Yucatan Channel during September 17 and moved inland on the Louisiana coast, its center a little distance to the right of the mouth of the Atchafalaya River, September 20. This disturbance advanced at the rate of about 8 miles per hour.

The meteorological and tide records at Mobile, Ala. (tide records from Pascagoula, Miss.), Port Eads, La., and Galveston, Texas, are shown on Plate IV. The storm tide began rising at Pascagoula, Miss., and Port Eads, La., about the same time on the afternoon of the 18th, when the center of the disturbance was nearly 400 miles distant in space and 40 hours in time. The rise which commenced at Port Eads and Pascagoula at 8 p. m. of the 18th had started from the southeast Gulf about 18 hours previously and had traveled about 500 miles at the rate of 28 miles per hour. By noon of the 19th there had been a rise at Pascagoula of 1.1 feet, and at Port Eads, of 0.8 foot, and by midnight of the 19th the water had risen 2.4 feet at Pascagoula and 2 feet at Port Eads. No material changes in the tide other than the regular change were shown at Galveston until the night of the 19th. The storm tide from the forenoon of the 18th to the forenoon of the 20th at Pascagoula, Miss., was about 2.8 feet, and at Port Eads, La., 2.2 feet, and at Galveston, Tex., 1 foot. The rise in the tide at Galveston all occurred during the night of the 19th-20th.

The wharves at Mobile were overflowed and the water was within half a block of Royal Street, the height of the water at that place being 8.7 feet.

The height of the water above mean Gulf level over the Louisiana coast region in the hurricane of September 20, 1909, has been determined by engineers of the Department of Agriculture in connection with the reclamation of marsh land (*18*). These records show the greatest height of the water in different parts



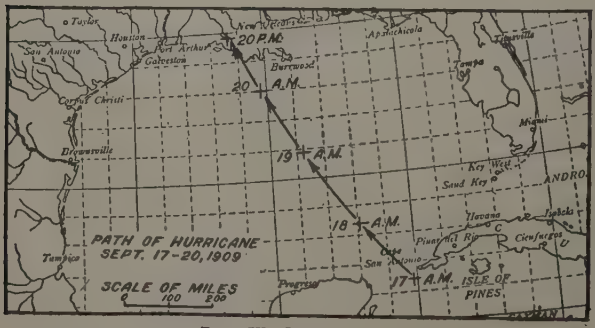


PLATE IV.—*I. M. Cline.*

of the hurricane with reference to the line of advance of the center, and from a study of these we may learn where to expect dangerous storm tides with the approach of a hurricane. The height of the water at several places in southeastern Louisiana during the hurricane of September 20, 1909, is shown in Figure 1.

Figure 1. Height of storm tide above mean Gulf level in right and left hand segments of the hurricane, September 20, 1909. This shows the area overflowed when storm moves inland at nearly right angles to the coast line.—*A. M. Shaw* (18) and, *M. Cline.*

seven parishes were flooded, the height of the water being 6 to 9 feet over the greater portion of the area. The actual height of the water over the land in the right-hand segment of the cyclonic area resulted from the accumulation of water forced forward by the winds and checked in speed by the marsh lands,

swamp forests, and levees. This is distinctly shown by the i
creased depth of 2 to 4 feet of water 30 to 50 miles inland fr
Burrwood and Port Eads. The depths of 7 to 10 feet occurred
points where the greatest resistance to the advancement of t
water, forced forward by the winds, was encountered. To t
left of the line of advance of the center of the hurricane, t
water did not get high enough at any point to attract attenti
and at Morgan City, La., near the center and in the left-ha
segment of the cyclonic area, the water was 0.1 of a foot bel
mean Gulf level, while 75 miles to the right of the center t
water was 5 to 7 feet above.

The damage to property by this storm amounted to $6,400,0
and 353 lives were lost.

October 13-18, 1910.—This disturbance moved into the Flori
Straits on the 14th, moved toward the northwest during t
15th, southward during the 16th, and then eastward to t
Florida Straits by the morning of the 17th, after which it mov
northward over Florida during the 18th. Barograph records
the French *S. S. Texas* from the 13th to the 17th confirm th
movement. We have no tide records for this disturbance. T
official in charge, Weather Bureau Office, Tampa, Fla., repo
the tide 6.6 feet below mean low water on the morning of t
18th, the lowest water of record, the cyclonic area at that ti
was moving northward with its center to the right of Tamp
After the passage of the center of the storm and its recur
northward, the water rose 10.1 feet, to 3.5 feet above mean l
tide.

August 13-17, 1915.—This hurricane moved across the weste
end of Cuba into the Gulf of Mexico during the forenoon of t
14th, traveled in a direct line and passed inland on the Tex
coast a short distance to the left of Galveston on the morning
the 17th. The disturbance advanced with a speed of about
miles per hour.

The wind, pressure and tides at Mobile, Ala. (tide at Fo
Morgan), Burrwood, La., and Galveston, Tex., are shown
Plate V. The storm tide began rising slowly at Galvesto
Burrwood, and Fort Morgan during the forenoon of the 15t
just 24 hours after the disturbance had moved into the Gulf
Mexico. These rises in the water over a coast line more th

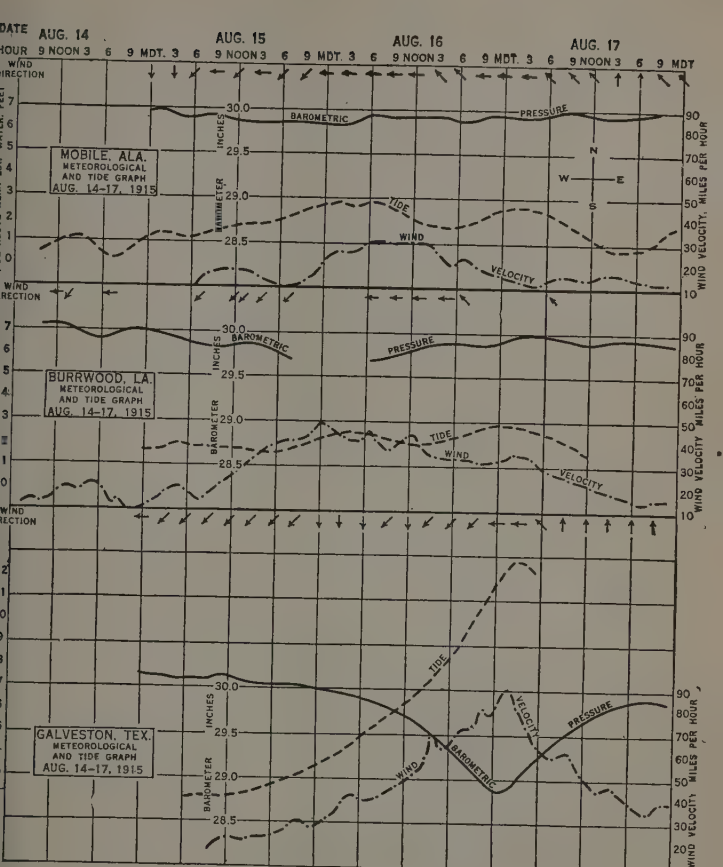


PLATE V.—For path and movement of hurricane, August 14-17, 1915, see figure 2.—*I. M. Cline.*

500 miles long all on the right of the line of advance of the hu
ricane resulted from waves started out from the region cover
by the hurricane in the southeast Gulf during the 14th. T
distance of the center of the storm at that time from Fo
Morgan and Burrwood was 450 miles and from Galveston, 7
miles. This would indicate that waves and swells were carri
forward in the front of the right-hand segment in the line
advance of the hurricane at a velocity of 40 to 50 miles per ho
and those going toward shore farther to the right of the line
advance traveled with a little less than half that speed. T
highest water at Fort Morgan, 2.8 feet, was recorded at 6 a.
on the 16th and showed a rise of 1.8 feet in 24 hours. At Bu
wood, 2.6 feet was recorded at 1 a. m. of the 16th, a rise of
foot in 24 hours. The tide did not rise after that to any exte
at either of these places, but high water continued at Fo
Morgan and Burrwood until the storm moved inland; the reg
lar tides were not obscured.

At Galveston the tide continued to rise and was 4.1 feet
6.30 a. m. on the 16th, a storm tide of about 3.1 feet in 24 hou
The center of the disturbance at this time was nearly 300 mi
from Galveston and 21 hours distant in time. The rise in t
water in front of the storm at this hour at Galveston was near
twice the rise of 1.8 feet at Fort Morgan, 300 miles to the rig
of the line of advance of the hurricane, and was three tim
greater than the rise at Burrwood. The water continued to r
at Galveston until about 3 a. m. of the 17th, when it was 12 fe
The tide changed very little at Fort Morgan and Burrwo
after 3 a. m. of the 16th and commencing at 3 a. m. of the 17
fell to about normal on the afternoon of that date.

The heights of the water above mean Gulf level along t
coast during this storm are shown in figure 2. This shows t
height of the water in feet and tenths along the Gulf coast
different distances from the line over which the center of t
hurricane advanced.

During the passage of this hurricane, the action of waves a
currents in moving objects in the open Gulf was brought o
by the movement of light and whistling buoys that were with
its range. Trinity Shoals gas and whistling buoy, weighi
21,000 pounds, anchored in 42 feet of water, with 6,500 pou

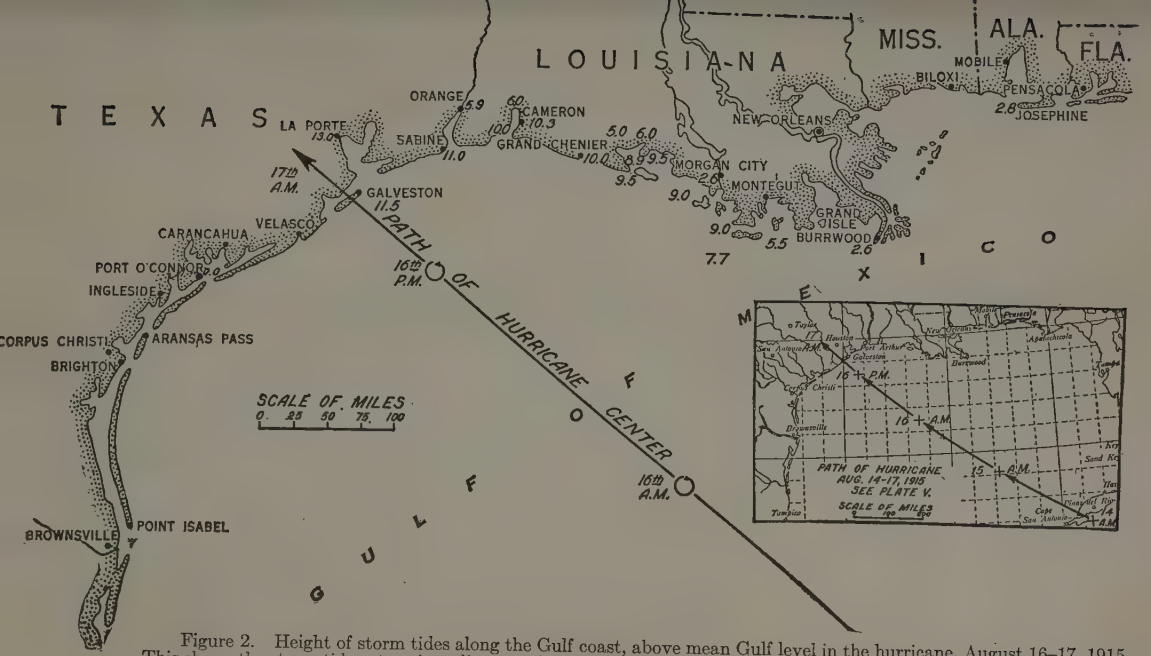


Figure 2. Height of storm tides along the Gulf coast, above mean Gulf level in the hurricane, August 16–17, 1915. This shows the storm tides at various distances from the center of a hurricane which moves through the Yucatan Channel and thence across the Gulf to the Texas coast.—*I. M. Cline.*

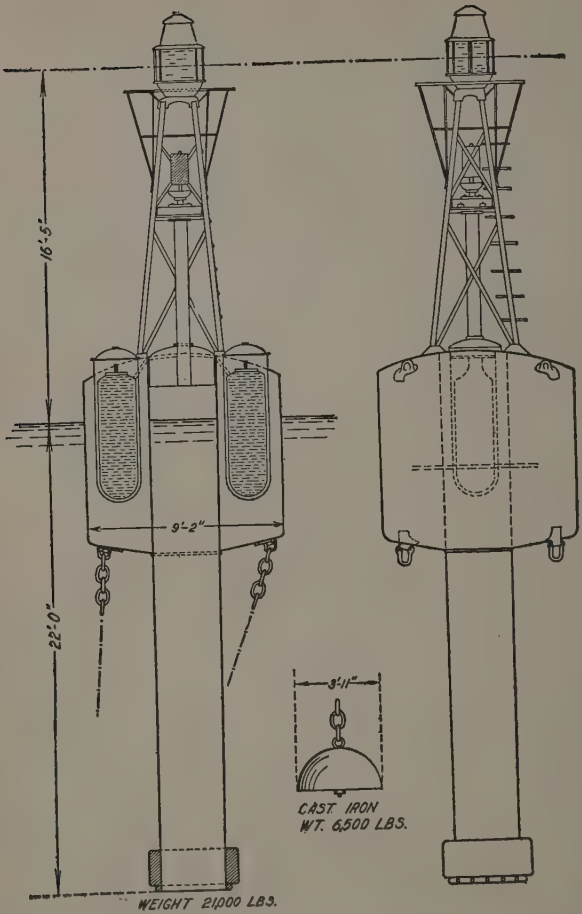


Figure 3. Design of gas and whistling buoys anchored at Trinity Shoals, L
ana coast; Galveston Bar, off jetties, and Heald Bank, Tex. Trinity Shoal
Heald Bank buoys are anchored in 43 feet and Galveston Bar in 36 feet of wa

inker and 252 feet of anchor chain weighing 3,520 pounds, was arried 8 to 10 miles westward of its proper location in latitude 9° 07′ N. and longitude 92° 15′ W. The shape and exposure f the buoy are shown in figure 3. The location of this buoy was 00 miles to the right of the line of advance of the center of he storm.

Galveston Bar gas and whistling buoy, same as shown, anhored at the end of Galveston Jetties in 36 feet of water was arried 4½ to 5 miles in a southwesterly direction from its proper ocation. This buoy was about 20 miles from the center of the torm.

A buoy of the same class, with the same moorings in 42 feet of vater, located on Heald Bank, 28 miles off the entrance to Galveston Bay, was not moved from its proper position, although its ights were extinguished. The Heald Bank buoy was a little to he left of the line of advance of the center of the hurricane. From the action of the water on these buoys we can get some nformation concerning the effects of currents and waves attending hurricanes.

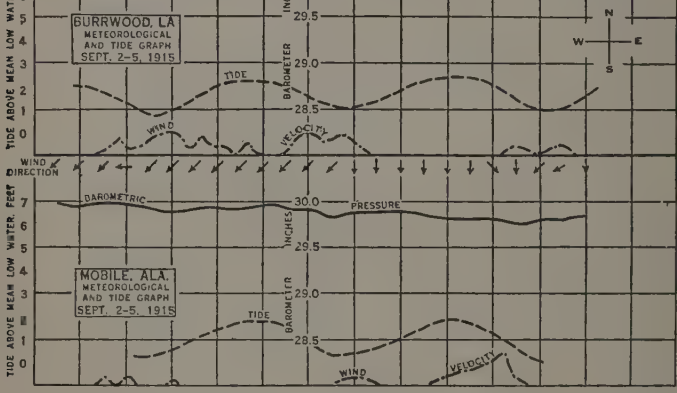
The property damage in this storm was about $21,000,000, nd 275 lives were lost.

September 2-4, 1915.—A disturbance of considerable intensity rossed western Cuba, moved into the east Gulf and recurving lowly, moved inland near the mouth of the Apalachicola River uring the early morning hours of the 4th. Pressure, wind and ide graphs for Mobile (tide, Fort Morgan), Ala., and Burrvood, La., are shown in Plate VI. These stations were located, Fort Morgan, 100 miles, and Burrwood, 200 miles to the left of he line of advance of the center of the storm. The tides at hese stations were not influenced in any manner by the disurbance and there was no high tide at Pensacola. Along the Florida coast, to the right of the line of advance high water revailed generally. At St. Petersburg, Fla., water was 4.9 feet bove any previous high water.

September 22-30, 1915.—This was one of the most intense urricanes in the history of the Gulf coast. The cyclonic area oved through the Yucatan Channel during the night of the 7th, and traveling northwestward moved inland on the Louisiana coast to the left of and near Grand Isle, La., during the

29th. This disturbance recurved slowly after crossing latitu
27° N. and moved slowly northward.

The pressure, wind and tides at Mobile (tide records F
Morgan), Ala., Burrwood, La., and Galveston, Tex., are sho
in Plate VII. The tide was about 0.8 of a foot above the p



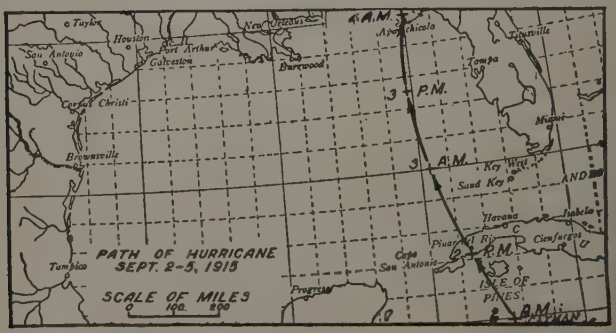
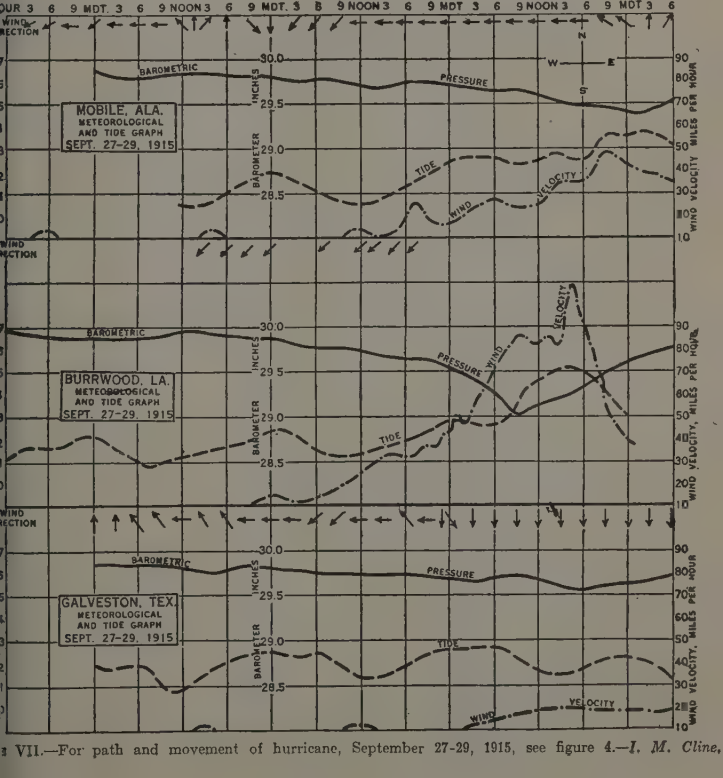


PLATE VI.—*I. M. Cline.*

dicted tide at 8 p. m. on the 26th. At 8 a. m. on the 27th the vater had commenced rising at Fort Morgan and was 1 foot above the predicted tide on the Gulf coast from Burrwood to Galveston; at 8 p. m. the excess was 1.1 feet. At 8 a. m. of the 28th, there was 1.5 feet of water in excess of the predicted tide at Burrwood and Galveston and 0.8 foot at Fort Morgan. At 8 p. m. of the 28th, when the storm was about 250 miles distant, there was a storm tide of 1.7 feet at Burrwood and 1.5 feet at Fort Morgan. When the storm began recurving to the right, the vater ceased rising at Galveston, and no storm tide was recorded



e VII.—For path and movement of hurricane, September 27-29, 1915, see figure 4.—*I. M. Cline,*

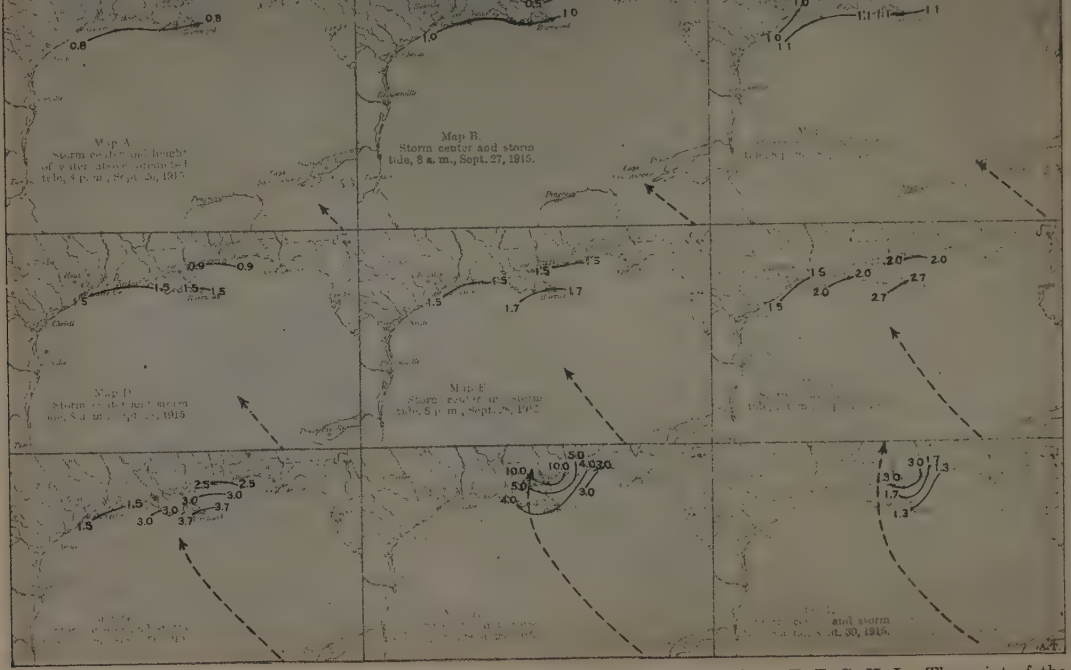
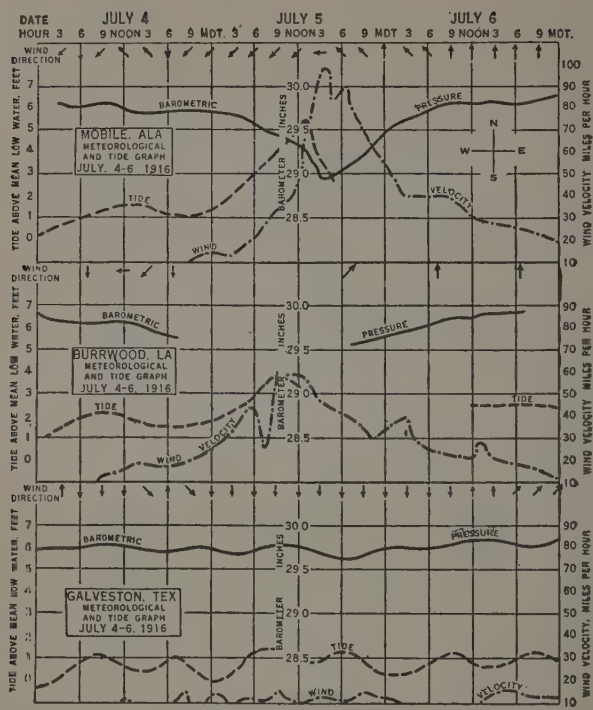


Figure 4. Storm tides on the Gulf coast, September 26–30, 1915. Maps A, B, C, D, E, F, G, H, I. The point of the arrow indicates the position of the center of the hurricane. The figures at the ends of the lines drawn near the shore show the rises of the storm tide on the coast as the storm advanced; that is the height of the water above the predicted tide at

Figure 5. Height of storm tide above mean Gulf level, in left and right hand segment of the hurricane, September 29, 1915. This shows the distribution of high water on the middle and east Gulf coast with a slowly recurving hurricane.—*C. W Okey,* (18) and *I. M. Cline.*

The damage resulting from this hurricane is estimated at $13,000,000, and 275 persons were drowned.

July 1-6, 1916.—The disturbance made its appearance in the Caribbean Sea on the afternoon of the 1st, moved almost in a straight line through the Yucatan Channel on the 3rd and reached the Mississippi coast late in the afternoon of the 5th. The storm covered a considerable area and was of great intensity.



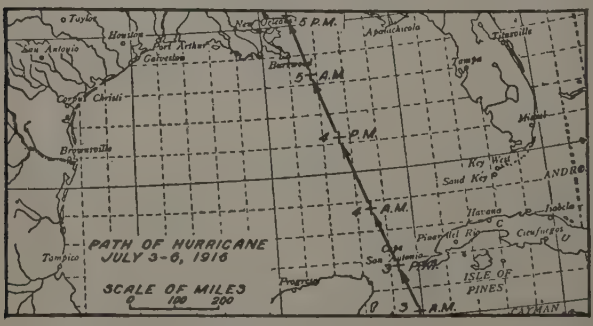


PLATE VIII.—*I. M. Cline.*

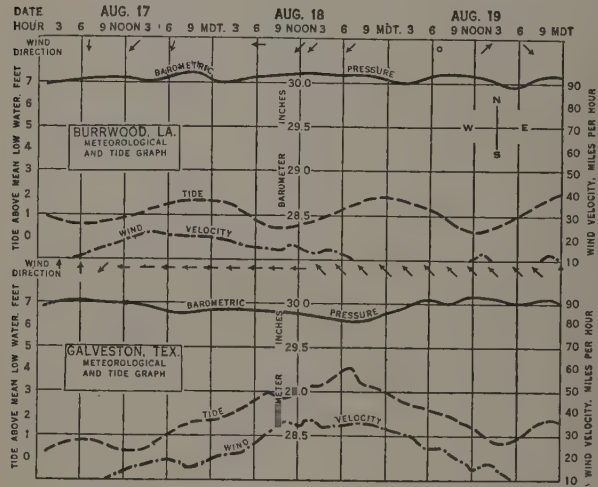
The wind pressure, and tides at Mobile (tide records, Fort Morgan), Ala., Burrwood, La., and Galveston, Tex., are shown in Plate VIII. The tide at Mobile and Burrwood was rising at noon of the 4th when the disturbance was centered 400 miles distant in space and 26 hours in time. This rise of water had traveled from the Yucatan Channel a distance of 500 miles in 18 hours in the front and to the right of the line of advance of the center of the cyclonic area. At midnight of the 4th the water had risen 1 foot at Burrwood and 1.4 feet at Fort Morgan. At 8 a. m. on the 5th the storm tide was 2.8 feet at Port Eads and Burrwood and 3 feet at Fort Morgan. The highest water at Fort Morgan was 5.3 feet and occurred at 1 p. m. of the 5th; at Burrwood the highest water was 3.8 feet at 10 a. m. of the 5th. Burrwood was about 25 miles to the left and Fort Morgan about 75 miles to the right of the line of advance of the center. The distance traveled by the center of the disturbance after passing Burrwood before coming in a line with Fort Morgan was 50 miles.

The difference in time between the passage of the crest of high water at Burrwood and Fort Morgan, 3 hours, would indicate speed of about 15 miles per hour, which is the same as the progressive speed of the cyclonic area. The location of these stations is such that no great banking up of water by physical obstruction was likely to have taken place. Therefore, these records serve as a good illustration of the heights reached by storm tides on the different sides of the hurricanes where the open space of water represents as nearly the condition in the open Gulf as we can expect to find. Fort Morgan was three times farther than Port Eads from the center. As the shore was approached the water banked up much higher, this being due to physical obstructions. The height of the water at Mobile was 11.6 feet, which is 6.3 feet above the actual height reached by the water at Fort Morgan. High water did not occur as far west as Biloxi and Pass Christian. The damage at Mobile and on the Alabama coast amounted to $2,500.000, and 12 persons were drowned. The height of the water at Pensacola, Fla., was 5 feet.

The damage at Pensacola amounted to $1,000,000. The storm did not influence the tide in any manner at Galveston, Tex.

August 12-19, 1916.—This disturbance passed through the Yucatan Channel into the Gulf of Mexico during the night of the 16th, advanced northwesterly in nearly a straight line, and moved inland on the Texas coast midway between Corpus Christi and Brownsville during the afternoon of the 18th.

We have no tide records in the vicinity of the center of this



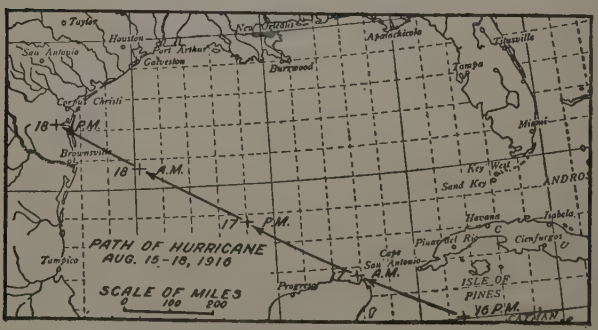


PLATE IX.—*J. M. Cline.*

hurricane, but wind, pressure, and tide records at Burrwood, La., 400 miles to the right, and Galveston, Tex., 250 miles to the right of the line of advance of the center of the hurricane, are shown in Plate IX. No appreciable influence was shown on the tide at Burrwood. At Galveston, 250 miles to the right of the line of advance of the center, the water commenced rising about 6 p. m. of the 17th, when the center of the disturbance was nearly 400 miles distant. The water that caused this rise must have started on its journey toward the Texas coast when the storm was passing through the Yucatan Channel and had traveled a distance of nearly 800 miles, showing a speed of about 40 miles per hour. The cyclonic area advanced at the rate of about 18 miles per hour. The water at Galveston rose steadily from 6 p. m. on the 17th until 6 p. m. of the 18th, when the height of the water was 4 feet, about 3 feet being storm tide. Galveston, at the time of the occurrence of the highest water, was 200 miles from the center, and a line drawn through Galveston and the center of the storm at that time crossed the line of advance at right angles. The advance of the hurricane was more prominently shown in the rise of the water at Galveston than in the pressure or wind changes.

The damage caused by this hurricane was estimated at $1,800,000, and 15 persons were killed or drowned.

September 21-29, 1917.—This disturbance moved through the Yucatan Channel into the Gulf of Mexico during the night of the 25th and advanced in a direction a little west of north toward the mouth of the Mississippi River. When within about 50 miles of Port Eads the storm began recurving to the right, and the center, passing about 50 miles to the right of Port Eads, La., moved inland to the right of Pensacola, Fla.

The pressure, wind, and tides for Pensacola, Fla. (the tides are drawn from the observations made by the observer of the Weather Bureau except the highest stage, which was obtained from the United States Engineers), Burrwood, La. (tide Port Eads), and Galveston, Tex., are shown in Plate X.

The changes in the height of the water with the advance of the hurricane are shown in figure 6. The changes in the tide in a recurving hurricane are shown in this case. The tide commenced rising at both Pensacola and Port Eads during the night

of the 26th and was 0.6 to 0.7 of a foot above the predicted tide at 8 a. m. of the 27th, when the disturbance was centered about 200 miles from Port Eads and 300 miles from Pensacola. At 8 p. m. of the 27th there was 1.0 foot of storm tide at both Pensacola and Port Eads. On the morning of the 28th the line of advance of the center, if continued, would have carried the center of the storm over Port Eads, which place had a storm tide of 2.7 feet, and Pensacola only 1.1 feet. At 10 a. m. reports from Pilottown showed the storm had shifted its course to the right.

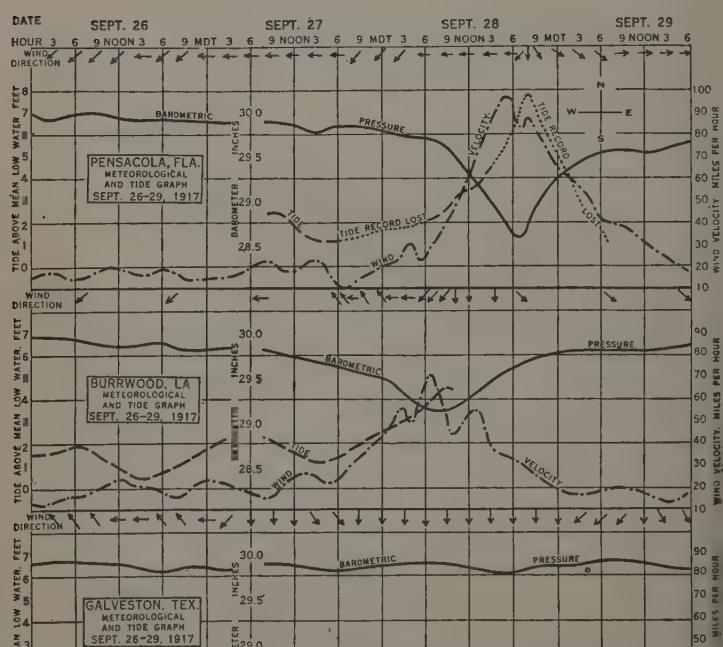


PLATE X.—For path and movement of hurricane, September 26-28, 1917, see figure 6.—*I. M. Cline.*

The tide began rising rapidly at Pensacola and by 2 p. m. t storm tide at that place was 2.8 feet. The storm tide abo 8 p. m. on the 28th at Fort Barancas, Fla., was 5.8 feet, t height of the water being 7.8 feet. The water in the river Mobile fell 5 feet below low water on the afternoon of the 28

The damage at Pensacola amounted to $170,000. This pla was near the center of the storm, but being to the left of t line of advance, suffered very little damage, notwithstanding t intensity of the hurricane.

August 1-6, 1918.—This disturbance moved through t Yucatan Channel into the Gulf of Mexico during the night the 4th, traveled in a northwesterly direction and passed inla over Lake Charles, La., during the 6th. The hurricane was sm but of marked intensity. We have no tide records for this stor but at Morgan City, 150 miles to the right of the line of advan of the center of the storm the tide rose 3 feet, and 28 miles w of the center, at Johnsons Bayou, there was a tide of 2.8 feet.

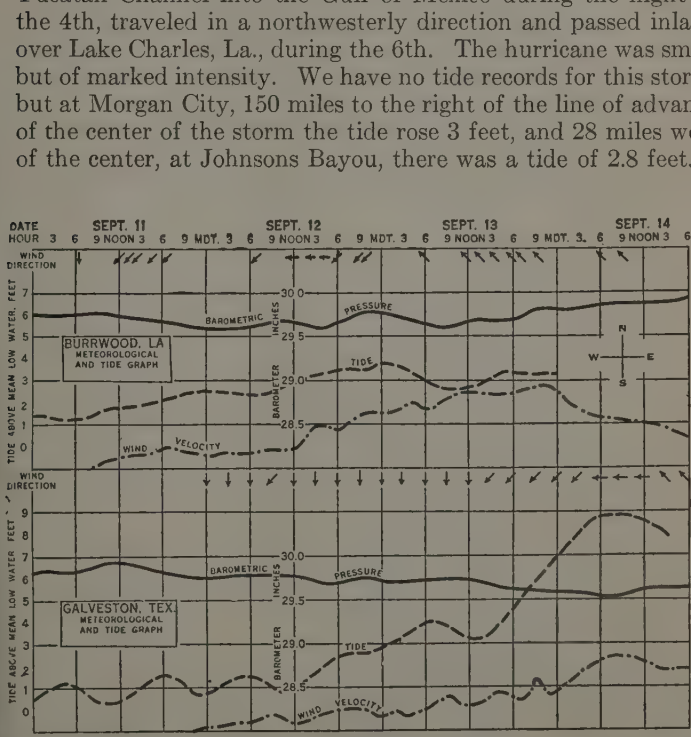


PLATE XI.—For path and movement of hurricane, September 11-14, 1919, see figure 7.—*I. M.*

The damage from the hurricane amounted to $5,000,000 and 34 deaths resulted.

September 6-14, 1919.—This disturbance passed through the Florida Straits during the night of the 9th, moved very slowly during the 10th, 11th, and 12th, with its line of advance pointing toward the Louisiana coast west of the Atchafalaya River. On the 13th the disturbance changed its course to the westward, moved rapidly in almost a straight course, and passed inland with its center a short distance to the left of Corpus Christi, Tex., during the afternoon of the 14th.

The pressure wind, and tides at Burrwood, La., and Galveston, Tex., are shown on Plate XI. The tide record at Galveston was incomplete after 12 noon of the 13th. The highest point reached by the water has been obtained from the United States Engineers and other records from tide heights telegraphed by the observer at Galveston with observations, and these data have been supplemented by other reports. We have thus been able to complete the tidegraph with a fair degree of accuracy. The long stretch of open water, more than 1,000 miles, traversed by this hurricane after entering the Gulf of Mexico, furnishes a splendid opportunity to study the changes in the stages of the water along the coast both in front and along the line of advance of the center of the hurricane.

The storm tides and their changes with the advance of the hurricane from the morning of the 11th until the afternoon of the 14th, when the hurricane moved inland, are shown in figure 7. There was a rise of 0.3 foot above the predicted tide at Burrwood, La., at 8 a. m. of the 11th, when the center of the storm was 400 miles distant. At 8 p. m. of the 11th the rise of 0.3 foot had reached Galveston, traveling from the longitude of Burrwood, about 500 miles in 12 hours, nearly 40 miles per hour, and the storm tide at Burrwood at this time was 1.1 feet. Galveston was at this time 600 miles distant from the center of the hurricane and Burrwood about 350 miles distant. By 8 a. m. of the 12th the storm tide was 1.7 feet at Burrwood and 0.7 of a foot at Galveston; and at 8 p. m. the height of the water in excess of the predicted tide was 1.9 feet at Burrwood and 1.6 feet at Galveston.

On the morning of the 13th the hurricane tide was 2.6 feet at

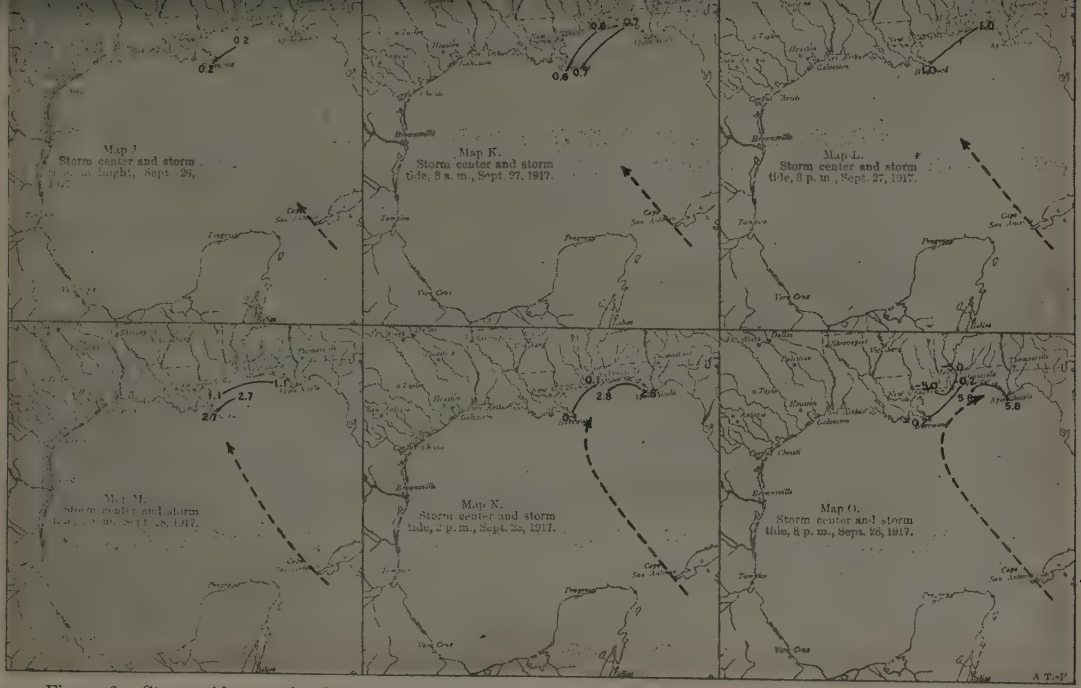


Figure 6. Storm tides on the Gulf coast, September 26–28, 1917. Maps J, K, L, M, N, O. The point of the arrow indicates the position of the center of the hurricane. The figures at the ends of the lines drawn near the shore show the rises of the storm tide on the coast as the storm approached; that is, the height of the water above the predicted tide at that hour. This is for a storm that recurved rapidly.

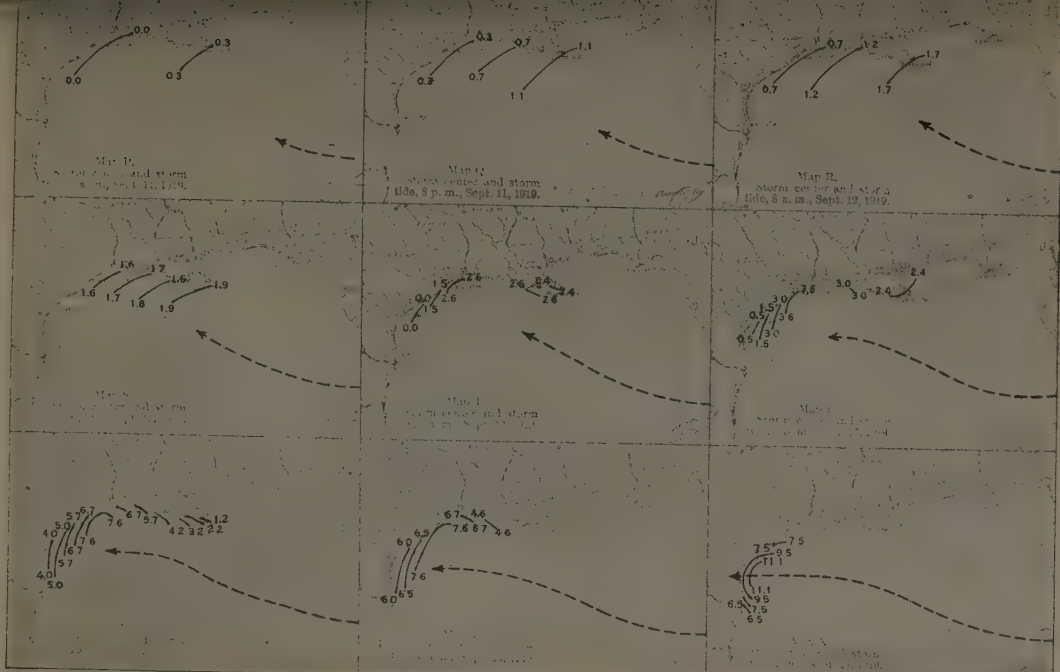


Figure 7. Storm tides on the Gulf coast, September 11–14, 1919. Maps P, Q, R, S, T, U, V, W, X. The point of the arrow indicates the position of the center of the hurricane. The figures at the ends of the lines drawn near the shore show the rises of the storm tide on the coast as the storm appoached; that is, the height of the water above the predicted tide at that hour. This is for a storm that moved coastwise.

Galveston, 300 miles in front of the center, and 2.4 feet at Burrwood, about 200 miles to the right of the line of advance of the center. No increase in the height of the water took place at Burrwood during the 13th, but at Galveston the storm tide at 8 p. m. was 3.6 feet, a gain of 1 foot in 12 hours; at this hour the water had commenced rising slowly at Aransas Pass, Tex. At 3 a. m. on the 14th the storm tide was 7.6 feet at Galveston, and 4 feet at Aransas Pass. At 8 a. m. of the 14th the height of the water had not changed at Galveston, but had risen 2 feet at Aransas Pass, during the preceding five hours and stood 6 feet. When the storm moved inland, about 3 p. m. on the 14th, there was a storm tide of 11.1 feet at Aransas Pass. The water, driven before the wind with the passage of the hurricane inland, banked up in places to depths of 12 to 16 feet.

This storm furnishes a good example for the study of the changes in the depth of the water along the coast in hurricanes which are moving coastwise. These heights are represented in figure 8. The rise of the storm tide in bays and estuaries to the right of the line of advance of the hurricane lags behind the rise on the coast. At Morgan City the highest water, 7 feet, occurred at 4 a. m. on the 14th, six hours after it had occurred on the near-by coast. At La Porte, Tex., near the upper end of Galveston Bay, the highest water, 8.5 feet, was at 1 p. m. on the 14th, about 12 hours after it had reached Galveston. At Carancahua, Tex., a tide of 10 feet occurred at 5 p. m., about 2 hours later than at Aransas Pass and at Ingleside, 12 feet at 10 p. m. on the 14th, nearly 9 hours after Aransas Pass.

During the passage of this storm Trinity Shoals gas and whistling buoy (described under hurricane of Aug. 17, 1915), anchored in 42 feet of water, was carried 2½ miles to the westward.

Galveston Bar gas and whistling buoy was carried 1½ miles to the southwest.

Aransas Pass gas and whistling buoy anchored in 42 feet of water, latitude 27° 50′ N., longitude 92° 02′ W., was carried 5 miles nearly parallel to the coast and a little in toward the coast. This buoy weighs 8,000 pounds, the anchor 5,000 pounds, and 252 feet of chain weighing 3,528 pounds.

At Sabine Bank Lighthouse, 15 miles off Sabine Pass, cast-

iron plates 5/8 inch thick, 27 feet above the surface of the wa were crushed in and bent up by the waves. This place about 125 miles to the right of the line of advance of the cen This is cited as showing the power of the wave in that part the hurricane.

The area along the Gulf coast, which has been flooded storm tides, is shown by the heights of the water given figures 1, 2, 5, and 8.

The damage caused by this hurricane amounted to $20,272, and 284 lives were lost.

During the 20 years 1900 to 1919 hurricanes on the coast the Gulf of Mexico have caused damage to property amount to $105,642,000, and 7,225 lives have been lost.

Concrete Knowledge of Winds in Hurricanes

Storm tides, in conjunction with hurricane winds, are s destructive agencies that it is of primary importance that have definite information relative to the distribution of winds in these disturbances. These winds are the physical age that furnish the energy that develops and carries the storm wa and tides to shores far in advance of the arrival of the hurrica and on the approach of the cyclonic area causes the inundat of our coasts and the destruction of property and lives over c siderable areas. Concrete information regarding the winds hurricanes that produce the swells and tides is limited a therefore, these are subjects that must be investigated in t connection. Definite knowledge of the action of these age might be obtained if the wind directions and velocities in hu canes could be charted simultaneously at a number of pla in the different quadrants of the cyclonic area. However, courses of hurricanes are mainly over water, and, therefore is not practicable to get simultaneous observations at a su cient number of stations to give us definite knowledge of actual winds in the different parts of the cyclonic area, and must look for some other method by which we can obtain t information. We have the theoretical ideal conclusions a charts giving the direction and velocity of wind in hurrica (*3*) (*5*), but these do not meet the requirements in the stu

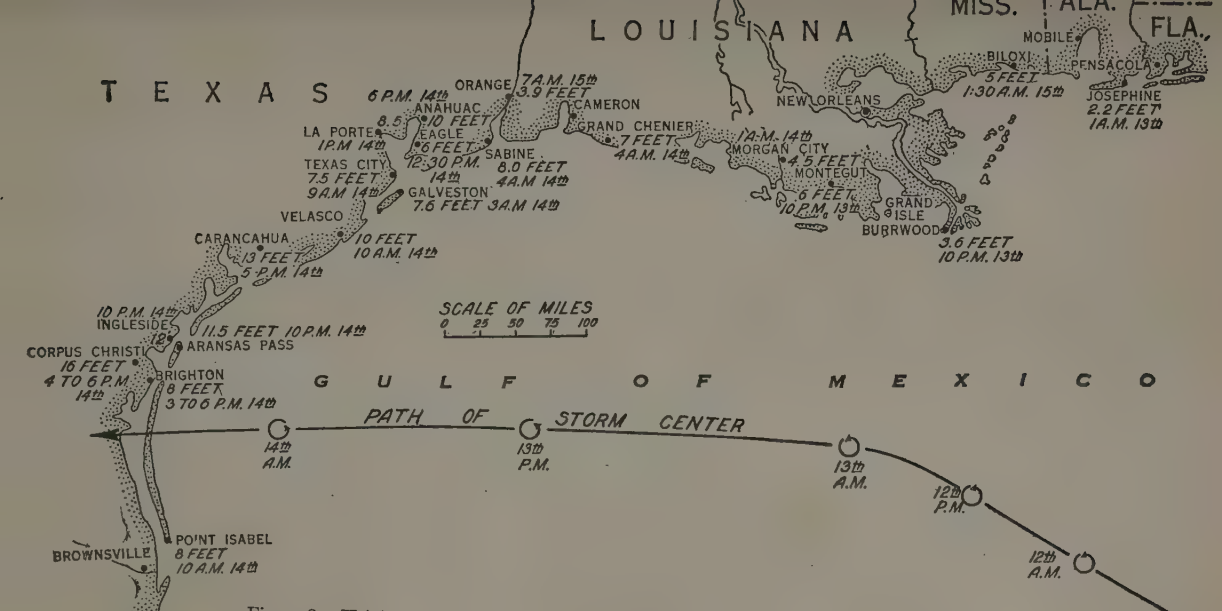


Figure 8. Height of storm tides along the Gulf coast above mean Gulf level and the time of their occurrence as related to the movement of the hurricane center through the Gulf of Mexico, September 11–14, 1919. This shows the storm tides in their relation to the path of a hurricane which moves in through the Florida Straits and thence across the Gulf to the Texas coast. The higehst tide at stations, 30 to 50 miles inland, on bays and estuaries, occurred 8 to 12 hours later than at points on the coast line.—*I. M. Cline.*

of this subject, for here we have need for knowledge of con ditions as they actually exist.

During the last 20 years two hurricanes have moved in s points on the middle Gulf coast, where sufficient records hav been kept to enable a very complete study of the actual win directions and velocities in different parts of the cyclonic area over water. These hurricanes while moving into extra-tropic regions, retained in a marked degree their tropical characte istics.

Bihourly Studies of Winds in Hurricanes

The hurricanes of September 29, 1915, and July 5, 191 moved inland with the center of the first near Grand Isle, La., an the center of the latter east of Gulfport, Miss., and we secure very complete automatic records at New Orleans (1), and Bur wood (2), La., Mobile (3), Ala., and Pensacola (4), Fla. Th southeastern portion of Louisiana, and the Mississippi, Alabam and Florida, coasts are low lying, near sea level, and sparsel timbered. The physical features of the area over which thes hurricanes moved, much of it being water surface, give as near ideal conditions for the study of the winds in the different quad rants of the cyclonic area during its passage as we can expe to find. These were typical hurricanes and both of great in tensity. The progressive velocities of the cyclonic areas wer determined for 100 miles after passing the latitude of Bur wood, La. The hurricane of September 29, 1915, advanced a the rate of about 12 miles per hour, and at this rate of progre the center was in the Gulf about 150 miles off the mouth of th Mississippi River at midnight of September 28. The hurrican of July 5, 1916, advanced with a velocity of 15 miles per hou and it was centered in the Gulf about 275 miles off the Missi sippi coast at midnight, July 4.

Based on a progressive movement of 12 miles per hour fo the September 29, 1915, hurricane, and 15 miles per hour fo the July 5, 1916, hurricane, maps were made every two hou during the passage of the hurricanes, using the automatic re ords at New Orleans (1), Burrwood (2), Mobile (3), and Pens cola (4), and observed pressure and wind directions from Morga City and Lafourche, La., and Pass Christian and Gulfport, Mis

he sustained direction and velocity of the wind being of imary importance in producing waves, the prevailing direction r the preceding hour and the average velocity for the two ours preceding the time of each map have been used on these aps, instead of the direction and velocity at the hour. This ves us on the composite charts the sustained velocity of wind, t only for the two preceding hours, but during the entire ssage of the hurricane. When the center of the hurricane of ptember 29, 1915, was 150, and that of July 5, 1916, was 275 iles distant from land, commencing at 2 a. m., at a time when e effects of the front of the storms were first being felt at urrwood, La., and Pensacola, Fla., and at the end of each two ours following, the position of the center of the storm was care-lly located geographically and charted from the automatic cords mentioned above. A line was drawn on each map, rough the center of the cyclonic area, the arrow pointing in e direction in which the storm was advancing at that time, viding it into right and left segments; another line was drawn rough the center at right angles to the first, dividing the storm to front and rear segments and also into quadrants.

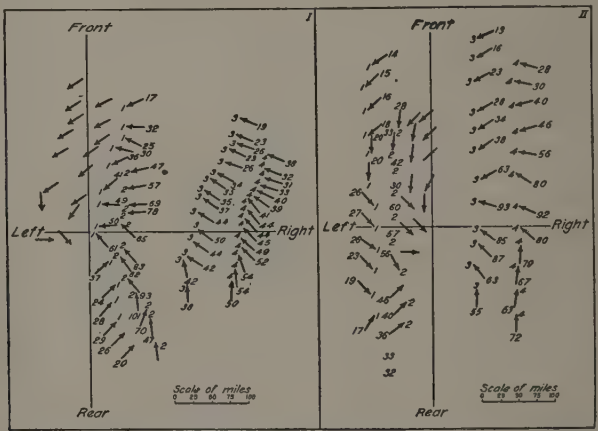
OMPOSITE CHARTS SHOWING WIND DIRECTIONS AND VELOCITY

From the maps we have prepared composite charts showing e actual winds, both direction and velocity, in different parts the hurricane, viz., Charts I and II.

Chart I shows the distribution of wind direction and velocity the hurricane of September 29, 1915, and Chart II shows the nd direction and velocity in the hurricane of July 5, 1916. these charts the long arrow points in the direction of the line advance of the hurricane and the intersection of the cross es represents the center of the cyclonic area. The figures 2, 3, and 4, at the points of the short arrows show the positions the stations they represent, on the charts, with reference to e cyclonic center at the times when the wind directions and locities were recorded. The arrow flies with the wind and ows the prevailing direction for the preceding hour. The ures at the butts of the arrows are the average wind velocities r the preceding two hours.

The composite wind charts for September 29, 1915, and July 5,

1916, were prepared in the following manner: The intersecti
of the cross lines on Chart I was placed over the center of t
cyclonic area as shown on the map at 2 a. m. September 2
1915, the long arrow on this chart pointing in the directi
toward which the cyclonic area was advancing at that time. T
prevailing wind direction for the preceding hour and the avera
wind velocity for the preceding two hours as recorded on t
map at 2 a. m. at New Orleans (1), Burrwood (2), Mobile (3
and Pensacola (4) were entered on Chart I, as shown by the fi



CHARTS I and II.—Composite wind charts. Prevailing wind direction for hour preceding and average wind velocity for two hours preceding time of observation in different parts of the hurricane. Chart I, September 29, 1915; Chart II, July 5, 1916.—*I. M. Cline.*

set of arrows and figures at the front of this chart. The po
tions of the numbers 1, 2, 3, and 4 at the points of the arro
bear the same relation to the intersection of the cross lines
this chart that the position of the stations they represent, occ
pied with reference to the center of the cyclonic area on t
2 a. m. map. Chart I was then placed over the 4 a. m. m
in the same manner and the second set of figures from the fro
were entered on this chart, representing the wind directions a
velocities as they appeared in that part of the cyclonic area

ne 4 a. m. map. This was repeated for each map, the wind irections and velocities at the four stations being entered at neir correct locations in respect to the center of the cyclonic rea, on Chart I, at the end of each two hours as the cyclonic rea advanced. The last set of entries in the rear of Chart I is or 6 a. m. September 30, 1915.

The same procedure was followed in preparing Chart II, com- osite wind chart for July 5, 1916, the first set of arrows and gures on this chart being 2 a. m. July 5, 1916, and the last set eing for 12 midnight, July 5, 1916. Fifteen maps were made or the September 29, 1915, hurricane, covering 30 hours, and here are 15 entries of wind direction and velocity from the ront to the rear of Chart I, for each station except Burrwood, ne record for that station being missing for the last three ntries. The hurricane of July 5, 1916, moved rapidly and iminished in intensity very soon after reaching land; there- ore only 12 maps, covering 24 hours, were used in preparing ne composite wind chart for that hurricane, and there are 12 ntries of wind direction and velocity, from the front to the rear f Chart II, for each station. There was very little change in ne intensity of these hurricanes during the periods covered by ne maps used in preparing the composite charts. Each entry f wind direction and velocity on Charts I and II has been made o that the figure at the point of each arrow is the same distance, n the same direction, from the intersection of the cross lines n these charts that the station which it represents, New Orleans 1), Burrwood (2), Mobile (3), and Pensacola (4), was from ne center of the cyclonic area on the map at the hour when nese directions and velocities were actually recorded.

The hurricane of September 29, 1915, recurved slowly during ne 30 hours for which the maps were drawn. The greatest eviation from a straight line in the 360 miles traveled by the urricane during this time was about 45 miles and occurred nidway of the period. The hurricane of July 5, 1916, moved in early a straight line.

Chart III shows the pressure distribution and winds at 2 p. m. eptember 29, 1915, midway of the series of observations on vhich Chart I, composite wind chart, for that hurricane is ased.

Chart IV shows the pressure distribution and winds at 1
noon, July 5, 1916, midway of the series of observations on whic
Chart II, composite wind chart, for that hurricane is based.

Charts I and II taken in connection with Charts III and I
show the relations of the winds to the isobars; both maps hav
been drawn from pressure reduced to sea level. These maps ar
considered preferable to composite pressure charts for thes
hurricanes.

Winds in Different Parts of Cyclonic Area

Wind directions and velocities shown on Charts I and I
approximate closely what would have been found to prevail

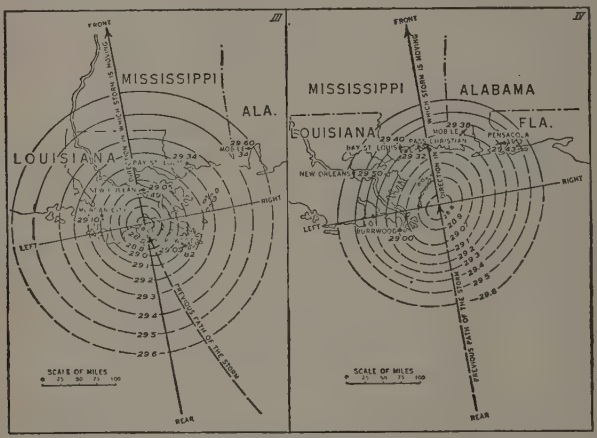


Chart III.—Hurricane, September 29, 1915. Pressure map at 2 p. m. midway of series used in preparing Chart I.
Chart IV.—Hurricane, July 5, 1916. Pressure map at 12 noon, midway of series used in preparing Chart II.—*I. M. Cline.*

simultaneous observations could have been taken at the poi
of each arrow on the charts and the direction and velocity of th
wind determined at the end of any hour during the progress
the hurricanes of September 29, 1915, and July 5, 1916, r
spectively.

In the hurricane of September 29, 1915, one that recurve
slowly, the wind velocity for four stations in the right-hand fro

quadrant averaged 43, and in the right-hand rear quadrant 52 miles per hour. The winds in the right-hand front quadrant near the path of the center blow across the line of advance, and 150 to 200 miles to the right of the line of advance of the center of the storm they blow at an angle of about 45° across the line of advance in the direction in which the hurricane is traveling, while in the rear right-hand quadrant the winds are mainly in the same direction as the line of advance of the hurricane. Effects of the wind, in the western segment of the September 29, 1915, hurricane, indicate velocities considerably less than those recorded in the right-hand segment. The highest wind occurred at a distance of 50 to 75 miles to the right of the line of advance after the passage of the center of the storm. The destructive power of the winds 40 miles east of New Orleans showed a greater force than at New Orleans. If we had automatic wind records for the September 29, 1915, storm from a point 50 miles east of New Orleans, such reports would show an increase in the wind velocities in the right-hand rear quadrant over those actually averaged from Chart I.

Burrwood, La., located in the right-hand segment, 50 miles to the right of the line of advance of the center of the cyclonic area, September 29, 1915, furnishes an excellent example for the study of the wind in that part of a cyclonic area at an individual station. Commencing at the time the center of the storm passed near that place, we get sustained wind velocities, in the rear right-hand quadrant, blowing mainly in a direction in line with the advance of the hurricane, as follows:

Sixty miles per hour or above prevailed for a period of 13 hours.

Seventy miles per hour or above prevailed for a period of 12 hours.

Eighty miles per hour or above prevailed for a period of 11 hours.

Ninety miles per hour or above prevailed for a period of 3 hours.

One hundred and eight miles per hour prevailed for 2 hours.

One hundred and sixteen miles per hour prevailed for one-third of an hour.

There was a gust with 1 mile at the rate of 140 miles per hour.

The wind velocity at Burrwood from 10 p. m., September 29, 1915, to 8 a. m., September 30, 1915, was not recorded, but the direction up to 9 a. m., September 30, 1915, continued mainly in the same direction as the line of advance of the hurricane. The wind velocity at 9 a. m., September 30, 1915, was 23 miles and by interpolating for the 11 hours following the 13 hours with a sustained velocity of 60 miles per hour or above, we find that an average velocity of 35 miles per hour prevailed. The average velocity was 85 miles per hour during the first 13 hours and 35 miles per hour for the next 11 hours after the passage of the center of the hurricane, making a total period of 24 hours with the average wind velocity exceeding 60 miles per hour. During this time the wind was mainly in the same direction as the line of advance of the cyclonic area. Burrwood continued, during this 24 hours, in the rear right-hand quadrant of the cyclonic area.

In the hurricane of July 5, 1916, which progressed in nearly a straight line, the wind velocity averaged for all stations, 48 miles per hour in the right-hand front quadrant, 72 miles per hour in the right-hand rear quadrant, 29 miles per hour in the left-hand front quadrant, and 34 miles per hour in the left-hand rear quadrant. In this storm the stations in the left-hand and right-hand segments were nearly equi-distant from the path of the center of the hurricane.

Pensacola, Fla., located in the right-hand segment, 100 miles to the right of the center of the hurricane of July 5, 1916, furnishes a good example for the study of winds at an individual station in that part of the cyclonic area. Commencing at the time the center passed that station we get sustained wind velocities blowing mainly in a direction in line with the advance of the hurricane as follows:

Forty miles per hour or above prevailed for a period of 24 hours.

Fifty miles per hour or above prevailed for a period of 19 hours.

Sixty miles per hour or above prevailed for a period of 10 hours.

Seventy miles per hour or above prevailed for a period of 5 hours.

Eighty miles per hour or above prevailed for a period of 3 hours.

For a period of 24 hours after the passage of the center of the hurricane the average velocity was 59 miles per hour, with the wind blowing in a direction mainly in line with the advance of the hurricane. During this time Pensacola was in the rear right-hand quadrant of the cyclonic area.

The foregoing records from Burrwood and Pensacola, both on account of their location with respect to the centers of these storms and their positions on the coast, may safely be assumed to represent the winds which prevail in those parts of a hurricane in the open Gulf. The velocities may be greater or less, depending on the intensity of the hurricane.

The high winds which occur, as indicated in the above hurricanes, in the right-hand rear quadrant of the cyclonic area, are sustained velocities which persist in the same direction as the line of advance of the hurricane during the life of the hurricane. Taking into account the diameter and progressive movement of the cyclonic area, we get a length of fetch of 300 to 400 miles in the rear right-hand quadrant of storms such as those represented in Charts I and II, with the wind 35 to 100 miles per hour for 24 hours, blowing mainly in the direction of the line of advance of the hurricane.

Development of Waves and Tides by These Winds

The wind velocities in the left-hand segment of a cyclonic area are never strong as compared with the winds in the right-hand segment (*3*) and are not long sustained in the same direction over the same area. Furthermore, the progressive movement of the cyclonic area causes the winds over the greater part of the left-hand segment to recede continually from the waves which these winds create; and thus their force for developing waves is diminished. Therefore there can be no great development of waves in this part of the hurricane.

In the right-hand front quadrant of the hurricane the winds near the center of the cyclonic area blow in a direction which carries the waves they develop across the line of advance of

the hurricane; but at a distance of 100 to 150 miles to the right of the line drawn through the center of the cyclonic area in the direction in which it is advancing the winds coincide more nearly with the direction of advance of the cyclonic area. Furthermore, in the front right-hand quadrant the winds change direction as a result of the progressive movement of the cyclonic area so rapidly that one direction does not persist over a distance or fetch of 75 miles during a period of as much as four hours. This condition, even with the high wind velocities that occur in this quadrant, would not furnish sufficient energy for large wave development.

In the right-hand rear quadrant the winds are more inclined toward the center and blow, in the main, in the same direction as the line of advance of the hurricane at sustained velocities averaging 72 to 85 miles per hour for 13 hours and 55 to 60 miles per hour for 24 hours. It is in this part of the cyclonic area that the greatest length of fetch exists, for here the high winds persist mainly in the same direction as the line of advance of the hurricane over a distance of 300 to 400 miles. The waves are under the influence of the wind from the same general direction not only over this entire distance but also for another 100 to 200 miles, for waves started in the rear do not pass out of the front of this area for many hours, during which time the fetch region has advanced a third to half a day's journey. For these waves then, the actual length of the fetch is 400 to 600 miles in cyclones of the size and intensity similar to those illustrated in Charts I and II. When the size and speed of the cyclone and the velocity with which the waves are moving forward are known, the length of fetch for these waves may be computed roughly, from the following equation by Dr. C. F. Brooks:

$$F = F + \frac{S}{W}F + \left(\frac{S}{W}\right)^2 F + \left(\frac{S}{W}\right)^3 F + \ldots\ldots\ldots\ldots$$

in which F is the length of fetch at any moment, S the forward speed of the cyclone, and W the progressive motion of the waves.

This sustained direction and velocity of the wind in the right-hand rear quadrant, prevailing during the life of the hurricane, furnishes the energy that develops and carries forward the large waves of long length which move on through the smaller and

shorter waves, pass on beyond the limits of the storm, and are carried by their inertia, in the line of advance of the hurricane, to shore long before even the front of the cyclonic area reaches there.

In this connection Eliot says (*1*): "The waves, when originally produced by the action of the moving air on the surface of the sea, move at a rate which is mainly dependent upon the velocity of the wind, and are hence called forced waves, because their rate of motion is determined by the body or action which produces them, viz, in this case the moving air. Waves when produced by such action do not cease when the action stops, or when they pass in their motion beyond the sphere of action of the producing winds. In such cases they pass onward in the same general direction as before, but gradually become smaller and smaller until at last they become imperceptible." He also in speaking of large waves, says: "Whatever explanation be adopted of the production of these large waves, there is no doubt of the general principle that air moving over a water surface always produces waves, and that the magnitude of the waves is dependent upon the extent of the water area over which they blow and upon the force of the winds. It is evident that the strength of the swell or the distance at which it will be sensibly felt in the open sea, will depend partly upon the strength of the producing winds and partly upon the distance over which the producing winds act with no considerable change in direction. The rapid movement of air over the surface of the sea gives rise, by some species of cumulative action to a continuous succession of large parallel waves so long as the winds are fairly steady in character. Waves that are produced in this manner travel steadily onward in the same general direction so long as they meet no obstruction, and if they pass beyond the area of strong winds, they decrease slowly in height and force." He also says, in speaking of the swell produced by cyclones in the Bay of Bengal: "It has been distinctly felt when the storm was at least 400 miles distant in space and 48 hours distant in time. In these extreme cases the storm was approaching the coast where the swell was observed."

It appears that no effort has been made to illustrate the differences in the relative sizes of the waves and swells produced

by the winds which prevail in the different parts of the cyclonic area. Col. Reid, as early as 1849, gave us a diagram illustrating the power of the winds of a cyclonic storm to give rise to swells moving outward in all directions from the storm area, (*1*) but

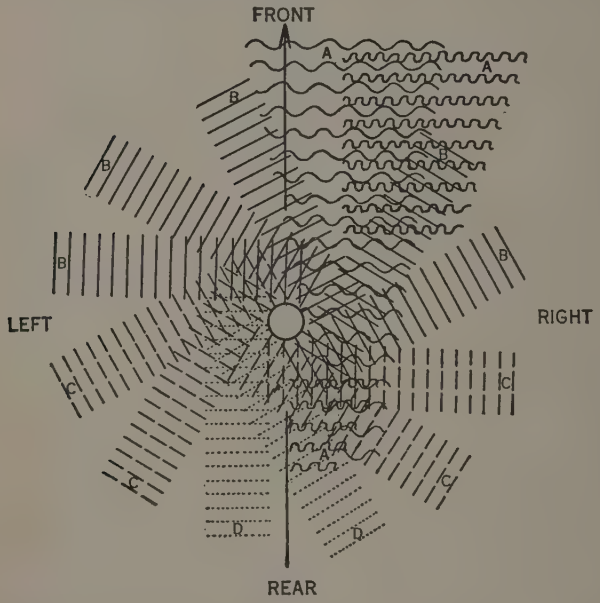


Figure 9

A. Swells of greatest length and magnitude, traveling in the line of advaace of the hurricane.
B. Swells and waves of moderate length and magnitude in the front segment of the hurricane moving outward to right and left of the line of advance.
C. Swells and waves of smaller length and lesser magnitude in the rear segemnt of the hurricane moving outward to right and left of the line of advance.
D. Swells and waves of least magnitude moving outward from the rear of the hurricane.—*I. M. Cline.*

he did not differentiate between the size and persistency of the swells produced by the winds in the different parts of the storm. With the wind directions and velocities which prevail in the different parts of the cyclonic area, as shown in the foregoing discussion and on Charts I and II, we are able to illustrate the

relative size and persistency of the swells which move out from the different parts of the cyclonic area and these are illustrated in figure 9, where the size of the swells going out from each part of the cyclonic area is shown to bear a certain and well-defined relation to the producing winds.

Conclusions

1. The waves and swells of greatest size and length are developed in the rear right-hand quadrant of the cyclonic area and move through the smaller waves in the front of the storm and are carried by inertia to shore in the direction in which the cyclonic area was advancing at that time. The waves sent out in other directions, being smaller and shorter, do not persist long after leaving the cyclonic area and soon flatten out and disappear.

2. The transference of water with the long waves and swells causes rises in the water along the coast, which increase as the storm approaches. The rise in the water on the coast in front of the line of advance of the cyclonic area, beginning 12 to 24 hours after the hurricane enters the Gulf, indicates the rapid movement of the waves through the storm area and across the Gulf. From a study of the movements shown on the different charts and figures with this paper, the speed varies from 30 to 45 miles per hour. The rapidity with which the waves travel depends both upon the extent of the cyclonic area and the intensity of the winds that develop the waves and swells. The water rises at the shore in the front, and to the right, of the point toward which the center of the hurricane was moving at the time the waves started on their journey.

3. The rise at shore, of the water from the hurricane, shows long in advance of any change in the barometer. Take, for example, the hurricane of September 11-14, 1919. When the barometer at Burrwood, New Orleans, Galveston, and Corpus Christi was either stationary or falling only a few hundredths of an inch, the water, first at Burrwood, later at Galveston, and then at Aransas Pass was rising in feet, telling the story of the movement, and of the change in the course of the storm as plainly as could possibly be told.

4. In using the information conveyed by the tides in fore-

casting the movements of hurricanes, the tides as predicted by the Coast and Geodetic Survey should be plotted for each hour whenever a storm appears in the Gulf. The height of the tide above mean low tide should be telegraphed from coast stations with each observation and these should be plotted over the predicted tides. The place where the water exceeds the predicted tides and continues rising is in the line of advance of the hurricane at the time that water started on its journey.

5. The intensity and extent of the hurricane is indicated when the disturbance is at a considerable distance in space and time, by the rapidity of the rise in the water and the extent of the coast over which the rise is taking place.

6. The time between the commencement of the rise in the water at shore and the arrival of the hurricane will depend upon the rapidity with which the cyclonic area is advancing and the intensity of the hurricane.

7. If the point of greatest rise shifts to the right or left, this indicates that the storm is changing its course in that direction toward which the increased rise is taking place.

8. When the crest of the storm tide is coincident with the crest of the regular tide the height of the water will be greater by more than one foot for hurricanes of equal intensity than when the crest of the storm tide is coincident with low tide, and in forecasting storm tides this must be borne in mind.

9. The regular tides are not obscured at any time by the storm tide, except at or near the point where the center of the storm moves inland, and then for only about twelve hours before the passage of the center of the hurricane.

10. The highest water occurs a few miles to the right, and about the time, of the passage of the center of the cyclonic area. At points on the coast some distance to the right of the line of advance of the center, the highest water occurs on a line drawn through the center of the cyclonic area at right angles to the line of advance of the hurricane, about the time of the passage of the center of the storm across that line.

11. The high water extends for only a short distance to the left of the point where the center of the storm moves inland. High water, however, is experienced to the right of the center for a distance of 100 to 200 miles.

12. The water commences rising at the shore toward which ne cyclonic area is advancing in less than 24 hours after the enter of the cyclonic area has entered the Gulf. The waves nd swells which give this rise must have moved through and ut of the rear right-hand quadrant of the storm area within 12 15 hours after the center of the storm entered the Gulf of Iexico. This indicates that with a fetch of 150 to 200 miles in ne rear right-hand quadrant of the cyclonic area the winds rnish sufficient energy to develop waves and swells of a size nd length that travel 30 to 45 miles per hour, reaching the iddle Gulf coast, 400 miles distant, in 10 to 15 hours, and the exas coast, 800 miles distant, in 15 to 20 hours.

13. Strong currents are created in the right-hand segment of ne cyclonic area which move in the main coastwise toward the ne along which the cyclonic area is advancing. The fact that vo gas and whistling buoys in August, 1915, and three in Sep- mber, 1919, were carried 2 to 8 miles nearly parallel to the ast, shows the force of these currents. If these buoys had been oved by waves they would have been carried in toward the ore and not along the coast.

Neither a Storm nor a Tidal Wave

14. The high water attending the hurricane is frequently re- rred to as a "tidal wave," or "storm wave," but it is not a wave any sense of that term. It is a cumulation of the water from ccessive "storm waves" reaching shore, covering a period of vo or more days, with a gradual rise which increases as the nter of the storm approaches. The "storm tide" results from ne physical forces of the hurricane, driving the large waves rward and transferring the water in the same direction as the ne of advance of the hurricane. In the open sea this storm de is not so great, probably not exceeding, in the greatest storm, ore than 5 feet. The obstruction formed by the coast line ts as a barrier and the water gradually banks up as it does gainst a dam across a stream. The rise in the water at shore frequently against opposing off-shore winds as was the case at alveston, Tex., in 1900 and in 1915, and at Corpus Christi, in 19. In such cases the off-shore winds force the water back the storm, retarding the rise; then when the winds shift and

come in with the storm, the rise in water is much more rapid a consequently more destructive. The diminished pressure ne the center of the hurricane will have some effect on the heig of the water. The weight of 1 inch of mercury is equal to th of about 1 foot of water. The increase in the height of t water due to diminished pressure at Galveston, for example, 1900, with the barometer 28.48 inches, could not have exceede under most favorable conditions, 1.5 feet, whereas the storm ti was 15 feet.

Records of Waves and Swells

There are no records available for use in the study of t individual storm waves and storm swells and groups which rea the coast and cause the storm tides. A knowledge of the si and speed of these would aid in the study of the movements water in hurricanes. A definite knowledge of these waves wou aid in determining the location and intensity of hurrican Observations should be made along the coast, especially wh hurricanes are approaching, of the speed and direction of wav and swells. The velocity of water waves and ripples is dete mined by the wave length. "Wave velocity = wave length wave frequency."

Fleming says this relation may be stated in another manne "We call the period of a wave the time taken in making one co plete movement. The period in time, is, therefore. inversely pr portional to the frequency. Hence, we can say that the wa length, divided by the periodic time, gives us the wave velocit * * *"

"A formal and exact proof of the law connecting speed a wave length for deep-sea waves requires mathematical reaso ing of an advanced character, but its results may be expressed a very simple statement by saying that in the case of waves deep water, the speed with which the waves travel, reckoned miles per hour, is equal to the square root of 2¼ times the wa length measured in feet * * *."

"The above rule for the speed of deep-sea waves, viz., wa velocity = square root of 2¼ times the wave length combin with the general rule, wave velocity = wave length multipli by the frequency, provides us with a useful practical meth

f finding the speed of deep-sea waves which are passing any xed point * * *." Count the number of waves which pass ne fixed point per minute and divide the number into 198; the uotient is the speed of the waves in miles per hour. Thus, ten waves per minute race past a fixed buoy, their velocity is early 20 (19.8) miles per hour. If V is the velocity of the wave feet per minute, and V' is the velocity in miles per hour, then

$V' \times \frac{5280}{60} = V$. But $V' = \sqrt{2\frac{1}{4}l}$ and $V = nl$, where "l" is the

ave length in feet and "n" the frequency per minute; from

hich we have $V' = \frac{198}{n}$, or the rule given in the text.

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Automatic tide records for Port Eads and Burrwood, La., and ort Morgan, Ala., have been furnished by the district engineers, nited States Engineers Corps, New Orleans, La., and Mobile, la. Staff-gage tide records for 1909, 1915, and 1919, and other nportant matter for Galveston, Tex., have been furnished by ne district engineer at Galveston, Tex.

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